



PowerSpout Low Head Turbine

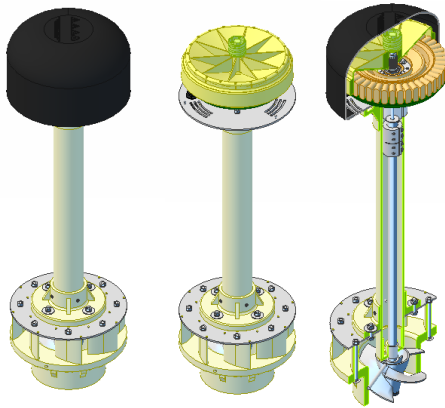
Variants LH and LH Pro

Installation Manual **(Low Head 1500 W maximum output/unit)**

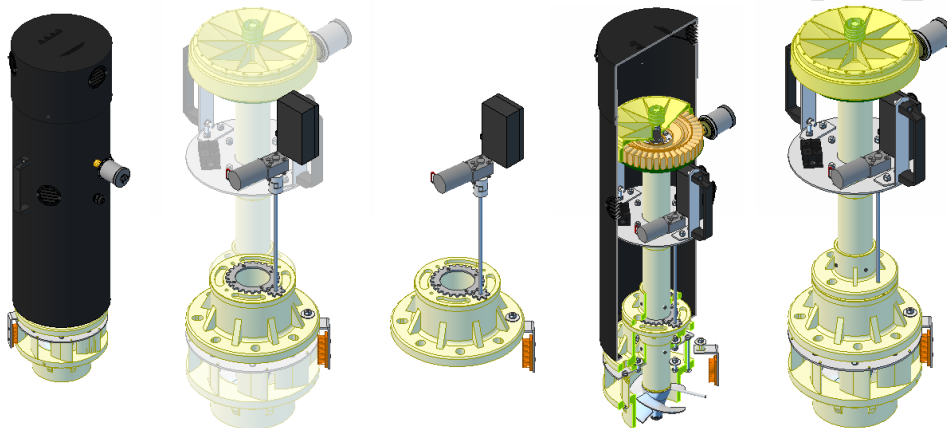


Domestic install pictures

Please read this manual carefully before beginning installation



PowerSpout LH – basic model for MPPT regulators and grid tie



PowerSpout LH Pro – premium model with auto-cleaner and greaser for MPPT regulators and grid tie

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PowerSpout Installation Manual

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1. Introduction

Congratulations on your choice of PowerSpout LH. This ingenious little device correctly installed and maintained will give you years of trouble free generation, avoiding the need for expensive generators or power bills. Not only does the PowerSpout LH give you renewable energy; it is also made of predominately recycled materials, making it one of the most eco-friendly generators available on the global market.

A PowerSpout LH turbine is more likely to be closer to your home than a PowerSpout Pelton. LH turbines will be installed on larger streams which tend to meander down valley bottoms where homes are typically closer. PowerSpout LH turbines are best employed by locating a part of the river that drops 2-5 m quickly (over a set of rapids). PowerSpout LH turbines have been shown to achieve up to 55% efficiency and can generate up to 1.5 kW on a suitable site; with multiple units the output can rise up to 15 kilowatts (kW).

Before commencing the installation process you should have selected the appropriate components and consulted your local regulations concerning use of water and undertaking electrical work. This manual includes information and links to relevant tools to facilitate this process. It should take no more than one day for a person to install a PowerSpout LH once flume, pipework and earthworks have been completed.

This manual will help guide you through PowerSpout LH assembly and the installation process to ensure it is installed correctly and runs efficiently. It starts with an overview of a micro-hydro system and then proceeds through each stage of the installation. Advice is also provided on basic maintenance to ensure safe and reliable supply of power for years to come.

Videos to introduce PowerSpout and demonstrate PowerSpout assembly and bearing replacement are available via www.powerspout.com. A video on the history of the Smart Drive generator over the last 20 years may interest many customers.

2. Components of your hydro system

A typical hydro system includes a good water supply, a generator and some type of electricity storage.

The generation capacity of your site is determined by the water supply, primarily by the vertical distance the water falls (head) and how much water flows in a given time (flow rate).

A rough estimate of generation potential for all PowerSpout turbines can be calculated as follows:

$$\begin{aligned}\text{Generation (Watts)} &= \text{head (metres)} \times \text{flow (litres per second)} \times 5 \\ \text{Generation (Watts)} &= \text{head (feet)} \times \text{flow (gallons per minute)} / 10\end{aligned}$$

Please refer to www.PowerSpout.com for more information. The Advanced Calculator tool will be updated for LH calculations soon, but in the meantime refer to Table 7 to determine performance at your site.

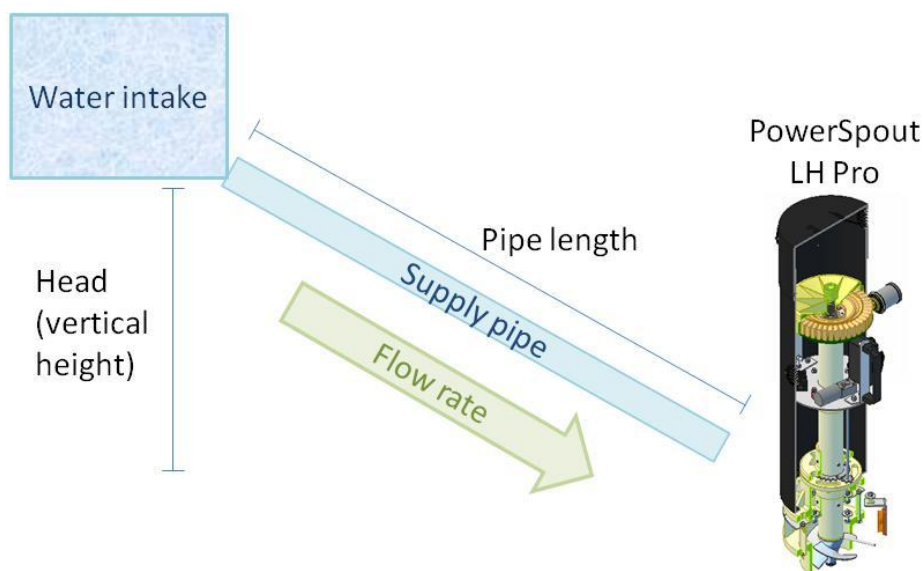


Figure 1. Water supply system

2.1. Setup for off-grid and grid-tied systems

Different systems use different configurations of components as shown in the diagrams below. Instructions for electrical connections are included in Section 5.

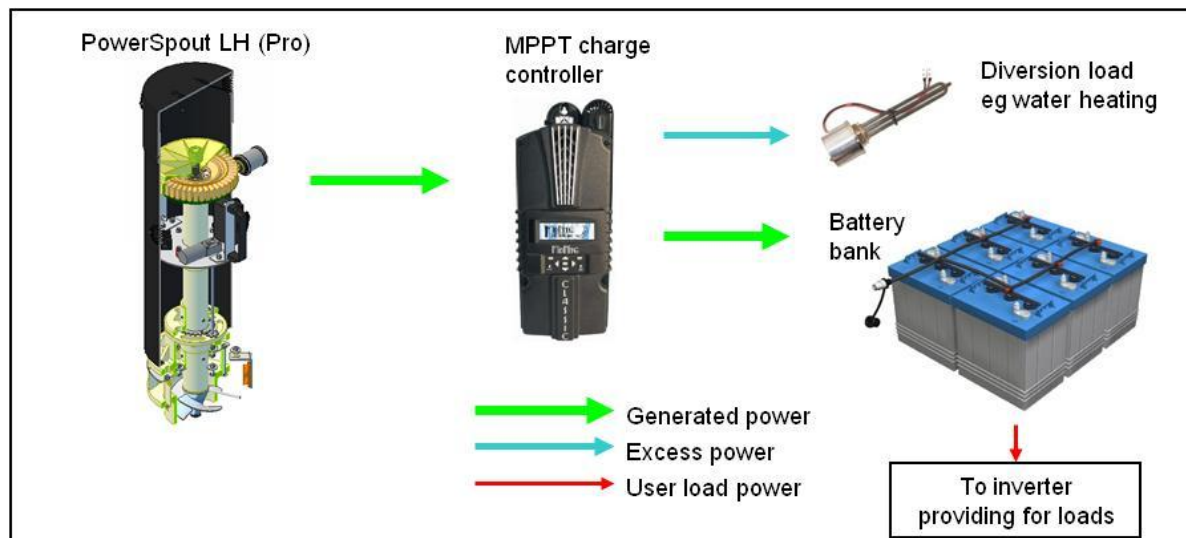


Figure 2. PowerSpout LH or LH Pro off-grid system setup

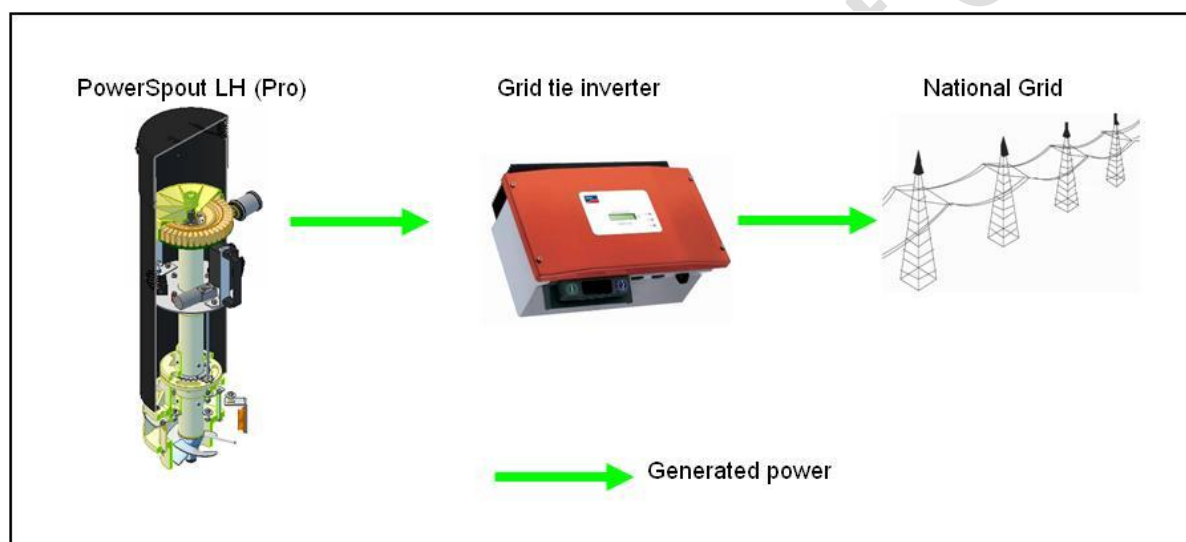


Figure 3. PowerSpout LH or LH Pro grid-tied (on grid) system setup

2.2. Generator (PowerSpout LH)

A micro-hydro generator like the PowerSpout LH converts the potential energy of a watercourse to electricity. This is achieved by drawing the water through a constriction which then has sufficient velocity to turn a propeller and hence the generator, which generates electricity. Micro-hydro generators produce 3-Phase AC power.

There are different versions of the PowerSpout LH available to suit different situations. These are briefly described in Table 1. Details of flow rates, generator types and generation potential on different sites are provided in Table 7 on page 68. Your PowerSpout LH will be configured for the flow rate you provide. The flow rate can drop to half the design (maximum) flow and the unit will still run, but produce less than half the power (see Section 11.1).

2.2.1. Body fairing

The body fairing is required to protect against rotational and electrical hazards while also preventing water ingress into critical components. A short fairing on the LH base model provides protection of the generator and the full body fairing on LH Pro provides additional protection of the automatic cleaner.

Table 1. Different versions of PowerSpout LH

Features	PowerSpout Low Head version	
	LH	LH Pro
Assembly required	yes 30 minutes	yes 100 minutes
Body fairing	short	full
Automatic guide vane cleaner	no	yes
Propeller cutter bar/cleaner	yes	yes
Limited upper voltage via a control circuit (This option is possible to special order)	no	no
Maximum cable voltage (depends on generator type and regulator fitted)	Approximately 150, 250, 400	Approximately 150, 250, 400
Typical MPP cable voltage (depends on generator type and regulator fitted)	Approximately 70, 120, 200	Approximately 70, 120, 200

2.2.2. Guide vane cleaner

An automatic guide vane cleaner is installed in the LH Pro. This is invaluable in situations where the water has a high leaf litter burden. It is also advisable in situations where the installation is checked infrequently. Turbines not fitted with a cleaner will need regular manual cleaning or there will be significant loss in performance over time. On our test site manual cleaning was needed every 6 hours for the LH turbine but the LH Pro ran without any need for cleaning provided larger sticks were prevented from entering by the installation by a suitable screen.

Where an automatic cleaner is used, a grate (see Section 4.8) to stop twigs is still needed or the cleaner can get jammed as shown below. This does not damage the power supply or drive motor, as it senses the overload caused by the jam and pulses the motor until the jam is manually removed. Remember **never** clean a jammed cleaner with the turbine running as the cleaner could start rotating without warning, trapping your fingers.



Litter will build up on the outside guide vanes quickly needing regular manual cleaning (LH)



Stick jammed in automatic cleaner (LH Pro)

2.2.3. Limited upper voltage

The LH and LH Pro turbine have a limited runaway speed for a given head of water. The maximum open circuit voltage (turbine unloaded electrically but running under full water flow) is normally about 2x normal maximum power point operating voltage.

The level of leaf/debris anticipated may direct the choice of PowerSpout LH or LH Pro, since only the latter has an automatic cleaner.

In off grid applications cable voltages can be as high as 250 V DC but operating voltages will typically be in the 80-120 V DC range for LH and LH Pro. Your regulator will do the conversion and you can charge 12, 24 or 48 V DC battery banks.

Cable voltages in grid-tied systems can be as high as 400 V DC but operating voltage will typically be in the range 160-200 V DC for LH and LH Pro.

Currently the Midnite Classic 250 MPPT charge controller/regulator manufactured by MidNite Solar is the only suitable option for use with PowerSpout LH in off-grid systems with a line voltage above 70 V DC. Where cables are short and losses low then MPPT regulators with an upper limit of 150 V DC may be used.

At time of ordering you will be asked to state the head, flow rate, battery voltage, cables size/length and regulator you are using so that the correct stator type can be shipped with your LH turbine. You can identify the correct stators for your site in the Advanced Calculator or from Table 7. Please make sure you complete the order form available from www.powerspout.com fully as no order can be processed if data is missing or unknown.

The commissioning check (Section 7.1) ensures that data errors are picked up that might otherwise result in regulator/inverter overvoltage damage. You must ensure these checks are completed prior to hook up.

2.2.4. AC or DC power

Contrary to the common myth, it is more efficient to send DC along a cable than AC for the same cable size. The only exception is where you already own a cable with 3 conductors suitable for 3-phase AC. If we rectified the 3-phase AC and sent it as DC down 2 of the cables then the losses would be more, the cable area used is less in this case. If you do have a 3 core cable installed then combining 2 of the cables into one and sending DC down these 2 cables is more efficient than sending AC.

2.3. Rectifier

A rectifier converts the 3-Phase AC produced by the micro-hydro to DC for supply to your battery bank or grid-tied inverter. There is a rectifier like this mounted inside the LH and LH Pro turbine.



2.4. Battery Bank

In off-grid systems a battery bank is required to store power. The voltage of the battery bank dictates the voltage of the system (12, 24 or 48 V DC) with 48 V being the most common. The quantity of batteries in the bank is dependent on the power requirements and the intermittency of power generation at your site. It is typical to have a number of batteries arranged in series to provide the desired voltage, and parallel to increase storage capacity. Lead-acid batteries are most commonly used, although many other types are also suitable.



Batteries can also be used in on-grid systems to provide power when the grid is down. If there is a grid power cut your PowerSpout LH on-grid inverter will disconnect itself from the grid so your home will also lose power. The extra cost to install a backup battery bank is difficult to justify unless you have frequent grid outages.

2.5. Inverter

Inverters convert the energy generated by a PowerSpout or stored by the battery bank to a voltage and frequency suitable for typical household appliances – usually 230/240 V in Europe/Asia/Australasia and 110/120 V in North America. Square wave inverters tend to be cheaper but pure sine wave inverters produce a higher quality waveform that is necessary for more sensitive electronics commonly found in the modern home. Induction motors (as found in most refrigerators, workshop machine tools and air compressors) tend to overheat when used on square wave or “modified sine wave” inverters. Large induction motors starting direct on line may fail to start even on large pure sine wave inverters which means you need to be careful when buying larger tools that have induction motors fitted such as a compressor, mill or lathe.



Outback inverter and regulator system

Inverters are available in a variety of power ratings (depending on the intended loads) and with a variety of surge ratings. A high surge rating allows loads with a high start-up power surge to run without overloading/tripping the inverter, or failing to start at all. Some inverters can also serve as charge controllers to regulate input from backup petrol/diesel/LPG generators.

2.6. Diversion Load: Hot Water Element

In off-grid situations your MPPT regulator can normally be set up to divert surplus power to your hot water heater. This will also ensure that your turbine runs at a constant speed and surplus power can be use rather than wasted. Many rural homes need to pump water, so pumping water at time of excess power is also good idea.



The other option if hot water is not needed is to have a display in your home so you can manually turn on more loads to use all the power available once your batteries are full.

2.7. MPPT charge controllers (regulators) for use with PowerSpout

Maximum Power Point Tracking (MPPT) regulators have become common in recent years mainly for the large solar PV market. These regulators can also be used on hydro and wind applications as long as additional voltage protection is provided or the upper maximum free spinning voltage is lower than the upper limit for the regulator to operate.

Not all MPPT regulators are the same and some can get confused when used on hydro turbines as the inertia of the turbine's rotating mass affects the stability of the MPPT tracking algorithm. Generally units that have a slower MPPT tracking rate will work well with hydro turbines.

Regulators such as the MidNite Classic 250 and Outback FM60/80 have been tested and work fine. These test documents are available at www.powerspout.com/compatibility. Many MPPT regulators are arriving on the market and other lower cost versions will be available in due course. EcoInnovation is happy to test MPPT regulators that are commonly available globally but we cannot confirm other brands will work satisfactorily unless tested by us.



MidNite Classic 250
MPPT regulator

MPPT regulators that have a wind/hydro mode are likely to work better as the makers have confirmed operation with generators that have rotational inertia and modified the tracking algorithms to get a good result. So be careful which MPPT regulators you buy: the cheapest one may not work well.

PowerSpout LH and LH Pro do not have additional voltage protection so make sure you supply correct site data, use the correct regulator and complete all commissioning checks prior to hook up (see Section 7.1). A voltage limiting version like the PowerSpout Pelton ME and GE may be produced in the future if demand warrants it.

Fuses

In order to prevent system damage through shorts and malfunctions, and for general ease of maintenance, it is recommended that a number of fuses be placed in the system for protection. Fuse ratings will be dependent on the overall power rating and type of components in your system.

The PowerSpout Pelton (PLT) Installation and Technical Manuals have more information on fuse sizes required.



3. Assembling your PowerSpout LH

As soon as you receive your PowerSpout LH please unpack and unwrap the parts and check them against the parts listed in the assembly instructions that follow. Parts missing will be evident on assembly. Please inform us immediately if you find any parts that appear to have been damaged in transit or are missing.

A video of an LH Pro turbine operating is available from www.powerspout.com
Products manuals are updated on a regular basis and should be used in preference to video material for ensuring compliance with the latest updates.

Please note images below are representative; small changes will occur over time as we continue to improve the product.

The two LH turbine variants have sub-assemblies which are common to all. What follows are instructions on how to assemble each sub-assembly and the turbine variant it is used on.

3.1. Tools you will need

These are not supplied as they are common globally

- 3.5 mm drill (or 1/8 inch)
- Hex head keys 5 and 3mm
- Socket set with sizes 8 mm, 7/8, 13 mm, 18 mm
- Adjustable spanner
- Medium and small screw drivers
- 13mm spanner
- Cordless drill and square drive
- Side cutters
- Small torque wrench (nice to have but not essential)



3.2. Spare parts kit

We recommend you buy at time of purchase the following spares:

- 2 x SKF spare bearings 6005-2Z
- 1 x M16 expanding bolt
- 1 x Nylon lower bearing bush
- 1 x 47mm OD shaft seal
- 1 x propeller plastic end cap
- 1 x sweeper brush
- 1 x grease cartridge



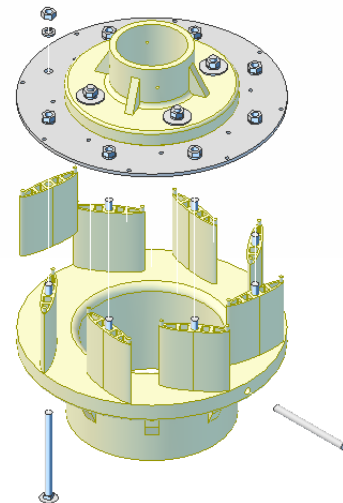
A bag of common spare fixings are supplied with your turbine, in case you lose some.

Table 2. Tightening torques for all fixings

Fixing type	Nm	Lbsft
M8 stainless fixings (metal to metal)	20.0	15.0
M8 stainless fixings (metal to plastic)	15.0	11.0
M16 expanding bolt	75.0	55.0
7/8 generator stator fixings	4.0	3.0
M6 Hex head bolt on large shaft coupling	17.0	13.0
M4 Hex head bolt on small shaft coupling	5.0	3.0
Self tapping fixings in plastic	0.5	0.4

3.3. Lower Guide Vane Assembly (Sub 01 – Both versions)

Locate the following parts shown in the picture and table below, the foam gasket LH018 and the self tapping fixings LH016 are not required at this stage (not shown in picture below).



Sub 01	Lower guide vane assembly	Material	Qty
LH010	Propeller flange	PVC	1
LH011	Propeller cleaner bar M8	Stainless Steel	1
LH012	Guide vanes	ABS	8
LH013	M8 coach bolts x 110mm (bolts, nut and split washer)	Stainless Steel	8
LH014	Laser cut lower disc	Aluminium	1
LH015	75mm lower flange	PVC	1
LH016	Self tapping fixings (flange to tube)	Stainless Steel	4
LH017	M8 bolt x 35mm (flange to lower disc, bolt, panel washer, split washer, nut)	Stainless Steel	4
LH018	Foam gasket to seal base of turbine into draft tube fitting. Foam gasket or adhesive foam is supplied.	Foam	1



Insert the long M8 coach bolts in turn and press the guide vane over the bolts as shown. The fit of the guide vane will hold them in place. Make sure the square protrusion on the coach bolt fits into the recess in the flange.



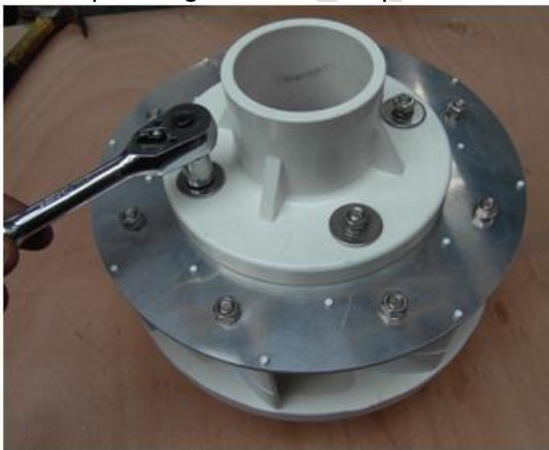
When finished it should look like this. Turn the plastic guide vanes so the outer edge is flush with the edge of the flange as shown. Also, you will notice on each vane a line and injection mark: this should point outwards for the best fit.



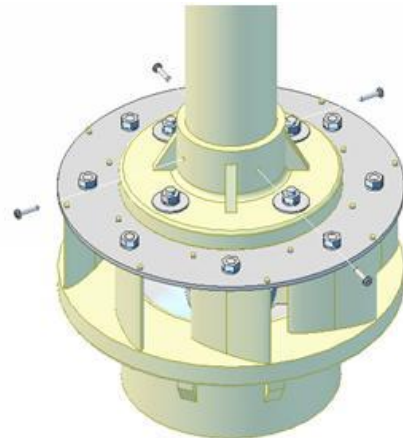
Place the lower aluminium disc on top as shown and ensure that the M8 threads protrude into the holes provided. Wiggle each guide vane while pressing lightly on the aluminium plate until all the guide vane locator pins align and fall into position.



Fit the M8 split washers and nuts and tighten as shown. If you do not have a torque wrench be careful not to over tighten them.



Install the PVC lower flange as shown with the M8 bolts, panel washers, split washers and nuts. Tighten nuts but please note these may need to be loosened at a later stage to ensure good propeller alignment.



The 3D image might help you check you have got it correct so far. Please note exploded animated views may show parts that are installed later. Congratulations you have completed the first part of the installation.

3.4. Shaft, bearing and propeller assembly (Sub 02 – Both versions)

Please note that some of the parts in this assembly are too long to fit in the same box, so will have been sent in a separate package. This means that they may not arrive at the same time.

Sub assembly 02 comprises a shaft, bearings, seal, bearing block and retaining nut already assembled as per the picture below (parts LH020-LH023).

The exploded view will assist you when bearing replacement is needed. Please note that the YouTube video of the bearing replacement procedure for the PowerSpout Pelton turbine is very similar. So refer to this video and the exploded views when you need to replace the bearings in all LH turbines. The only difference is the addition of the seal that is needed to stop the grease working out through the bottom bearing as the shaft is vertical in this design.

If ordering spare bearings be careful to advise that your turbine is a PowerSpout LH, or incorrect bearings may be sent. We would advise you order a spare set when you purchase your turbine so you always have a set on hand. Spare part LH021 includes 2 bearings and new seal.



Sub 02	Shaft, bearing and propeller assembly	Material	Qty
LH020	Bearing block (75.2 x 30 step 67.5mm)	Aluminium	1
LH021	Rear, Front bearing 6005 and seal OD47 ID25mm	Steel/Nitrile	1 set
LH022	SD Shaft D25 x 263mm long	Stainless Steel	1
LH023	Shaft retaining nut 32AF x 5mm thick	Steel – zinc plated	1
LH024	Drive shaft tube D19mm x 720mm long	Stainless Steel	1
LH025	Drive shaft coupling D25 to D19	Aluminium	1
LH026	Drive shaft coupling fixings M6 Hex head	Steel	4
LH027	Outer shaft D75.5mm	PVC	1
LH028	3 x M5 fixings and 1 x grease nipple	Stainless Steel/Steel	1 set



Locate the parts as shown. If you have anti-seize paste available smear this lightly on the mating surfaces and the thread of the fixings (use grease if you do not have the correct paste). This will make it easier to get apart when you need to replace the bearings in the future.

Assemble parts as shown and using a 5mm Hex key to tighten the 4 x M6 fixings.



Insert the shaft and bearing block into the PVC outer shaft and align the 2 large holes as shown.



Insert the grease nipple as shown. For LH Pro this nipple will be removed later and the auto lubricator fitted. This nipple is used to manually charge with grease prior to removal.



Insert and tighten the remaining 3 x M5 fixings as shown.

These M5 fixings will need to be removed at times to allow other parts to slide over the top as needed.

Congratulations you have completed the second part of the installation. Instruction on how to assemble the shaft and bearing block parts follows, since this will be needed for bearing replacement in the future.

3.4.1. How to assemble the shaft and bearing block parts after servicing



Locate the parts above by removing the bearing block and shaft from your turbine. You will need new bearings and seal.

The spare parts kit for this turbine has all the parts that should be replaced every time the bearings are replaced.

Punch out the old bearings using a long bolt as a punch. Thoroughly clean the bearing block and shaft so it is free of grease and grime. Press in the new bearings with a hand press (if you have one) or tap on the outer race with a hammer until the bearing is fully seated.

For the bearing that is recessed you can normally locate a large socket to use as a drift to press or tap the bearing home on the outer race. Pictures of both bearings being pressed home are shown below.



Clean all contact surfaces with methylated spirits.

Apply one drop of bearing retaining compound to the protruding inner bearing surface and the rear shaft bearing surface as shown, and spread evenly.

Place the shaft into the bearing block and tighten the nut. Check the shaft spins freely; do not over tighten the nut.

A new seal can then be pressed into position; a short piece of tube may be needed to do this.



3.5. Lower bush and Propeller assembly Shaft (Sub 03 – Both versions)

Identify the parts below in addition to the 2 assemblies you have made so far.

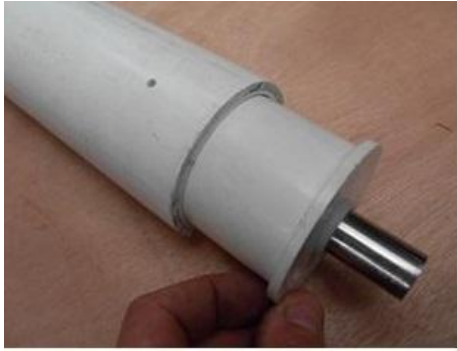


Note that the white nylon bush is a spare part and should be kept in a safe place out of sunlight. Replace this bush every time you replace the turbine bearings.

Sub 03	Lower bush and Propeller assembly	Material	Qty
LH030	Shaft to lower bush reducer and bush	PVC/Nylon	1
LH031	Lower bush 25mm OD 19.5mm ID (and 1 spare)	Nylon	2
LH032	Self tapping fixing (shaft to reducer)	Stainless Steel	1
LH033	Propeller D154mm and plastic end cap	Stainless Steel/plastic	1
LH034	M16 expanding bolt (drive shaft) to prop	Yellow zinc plated steel	1

You also need to locate the 4 self tapping stainless fixings listed in Sub 01 but not yet used.

The next step is to assemble all the parts above.



Insert the bush reducer as shown and tap all the way home.



Drill a 3.5mm (1/8) hole through the pipe for the self tapping fixing. There is already a guide hole on the outer PVC tube. Please note there may already be a hole in the bush reducer from when the turbine was assembled in our production facility, do not try to line up these holes, it is easier just to drill a new one.



Insert the self tapping fixing as shown. Then remove it and put it back in later, once this part is assembled into the guide vane assembly.



Insert the outer tube (and assembled parts so far) into the lower guide vane assembly as shown. Then stand the unit up on the floor with the threaded shaft on the ground and the stainless tube facing upwards.



Gently (tap with a mallet) the propeller into place as shown until the top of the stainless tube is flush with the bottom of the recess in the propeller.



Insert the M16 expanding fixing, smear with grease or anti-seize first to assist with removal in the future, and tap it fully home. Tighten with a socket as best you can, it will be tightened correctly later.



Put the assembly back on a bench, push on the propeller until the top of the blade almost touches the propeller cleaner bar as shown in the picture.



Drill a 3.5mm (1/8) hole through the pipe for the self tapping fixings.

Please note there may already be holes in the PVC tube from when the turbine was assembled in our production facility, do not try to line up these holes, it is easier just to drill a new one.



Insert the four self tapping fixings as shown. Loosen the 4 x M8 fixings, ensure the blade spins freely and then tighten them properly. If the cutter bar is just hitting the top of the blade, do not worry: it will bed-in once it is running. If there is a significant rub then the propeller will need to be loosened and moved away a little until it spins freely.



Tighten the nut as best you can at the moment. You will need to tighten it fully once the generator rotor is attached and with the help of an assistant you can fully tighten the nut; this expands the shaft which ensures the propeller is firmly attached to the shaft, but still relatively easy to remove in the future for servicing.

Note the slot in the end of the fixing is to assist in undoing the fixing in the future. If you notice that the fixing is turning but does not tighten/loosen then insert a flat screwdriver through the middle on the socket, and turn the socket with a pair of grips to remove or tighten the nut.

To remove the propeller, remove the nut (you may need to use the screw driver technique if it just turns and does not undo), and punch the M12 threaded stem into the drive shaft. With an assistant holding the rotor it should be possible to wiggle the propeller off the shaft.

If it has been on for many years and has seized, then simply remove all fixings off the drive tube assembly and remove the propeller, PVC tube and drive shaft complete. Then you can hold it in a vice and apply more force to separate the seized parts.

Once the final tightness checks have been completed you can press the plastic end cap home, this is normally the very last part to assemble, so do it later as it stands flat on the ground with this part not installed.



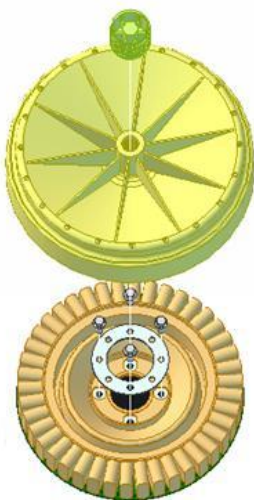
Congratulations you have completed this part of the installation, and your work to date should look like this.



3.6. Smart Drive generator assembly (Sub 04 – Both versions)

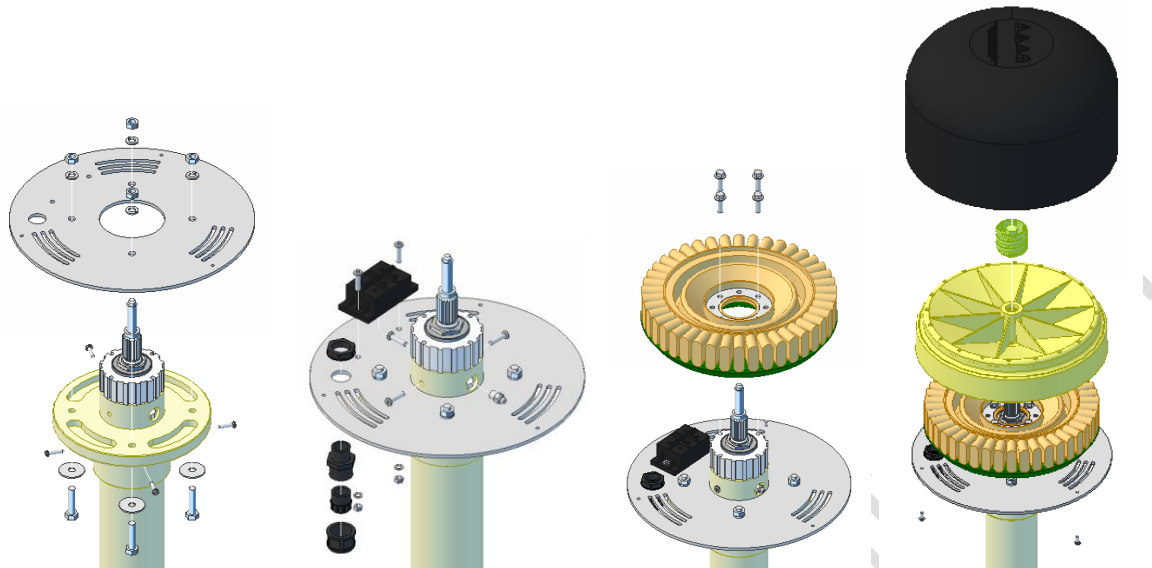
Locate the parts below as you will need them soon

Sub 04	Smart Drive generator assembly	Material	Qty
LH040	Smart Drive stator D250 x 60mm	GF30PP, copper, steel	1
LH041	Smart Drive rotor D275 x 68mm	GF30PP, ferrite, steel	1
LH042	Smart Drive backing plate (attached to stator)	PP	1
LH043	Smart Drive extractor knob (or bolt fixing may be used in some cases)	GF30PP	1
LH044	Smart Drive galvanised steel washer	Steel	2
LH045	Smart Drive ¼ BSP fixings	Steel (zinc plated)	4



3.7. Electrical assembly and enclosure (Sub 05 – LH only)

Identify the parts below in addition to the assemblies you have made so far.



Sub 5	Electrical assembly and enclosure (LH only)	Material	Qty
LH050	100 amp 3-phase rectifier	Electrical	1
LH051	300mm top plate	Aluminium	1
LH052	M5 x 20mm rectifier fixings (bolt, nut, split washer)	Stainless Steel	2
LH053	2m of 20 amp cable/flex	Copper	1
LH054	Vented top fairing + fixings	LDPE/Stainless	1
LH055	Cable entry gland	various plastic	1
LH056	75mm top flange	PVC	1
LH057	M8 bolt x 20mm (flange to lower disc, bolt, nut, split washer, panel washer)	Stainless Steel	4
LH058	Self tapping fixings (flange to outer shaft)	Stainless Steel	4

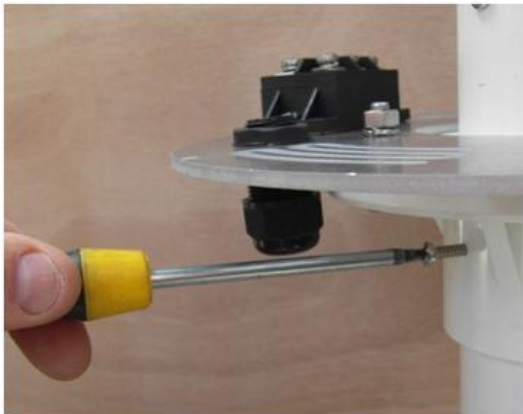
Assemble these parts as shown in the picture.
When connecting the rectifier to the top plate, smear a thin layer of heat transfer compound on the base of the rectifier for a good thermal connection.





Then slide this assembly over the top of the assembled parts so far; you will need to remove the M5 fixings and grease nipple to do this, then put them back in. Position it 75mm (3 inch) from the top of the white PVC pipe.

Drill 4 x 3.5mm (1/8) holes through the pipe for the self tapping fixings. There is already a guide hole on the outer PVC flange. Please note there may already be holes in the PVC pipe from when the turbine was assembled in our production facility, do not try to line up these holes, it is easier just to drill a new one.



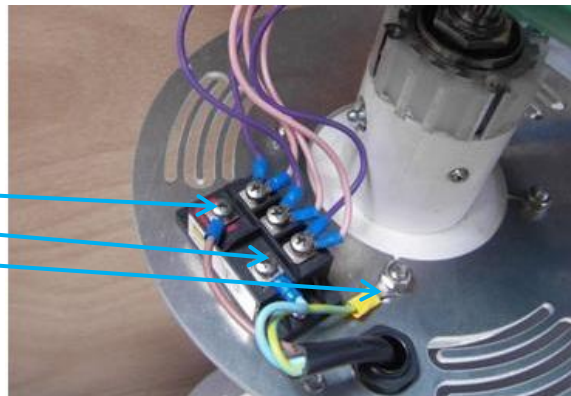
Fasten in place with the 4 self tapping fixings as shown.



Connect the outgoing cable to the rectifier as shown.

Delta connection shown in picture.

Red/Brown to rectified positive
Blue/Black to rectified negative
Green to metal plate, earth connection



Position the stator and attach the AC wires onto the rectifier; these connections can be either Star or Delta. Refer to the generator selection table (Table 7) to check that the generator code number is correct for your vertical drop and model, and see if you need a Star or Delta connection.

On the base of the stator backing plate, you will notice that each wire is numbered 1, 2, 3, 4, 5, or 6 where it exits the backing plate.

For Delta connection (as shown on previous page) connect into pairs and wire 1&5 then 2&6 then 3&4 together, and then connect each pair of wires onto the connection point; order is not important. Each wire in the pair will be a different colour (not necessarily the colours shown here).



For Star connection take wires 1,2,3 (all the same colour) and make a Star point by bolting the 3 wires together; insulate this connection point and cable tie out of the way. The other 3 wires (all the same colour) connect onto the connection points; order is not important.



Make the star point as shown (left)

Insulate with 5 layers of PVC tape as shown (right)

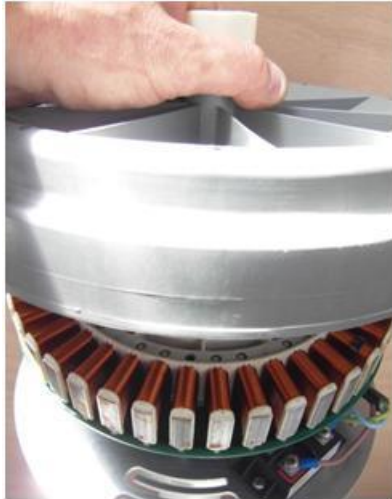


This picture shows a Star connection. Note the taped up star point.



Position the stator and secure in place with the 4 fixings

Charge the bearing block with grease until you can just see a ring of grease appear out of the top bearing.



Press the extraction knob into the magnetic rotor. Apply anti-seize or grease on the splines of the shaft and the inside splines of the rotor. Attached the magnetic rotor, there is a bit of a trick to this, waggle the rotor and turn the knob at the same time and the thread engages. Turn the knob until the rotor magnets are fully over the stator. Do not over tighten, finger tight only.

Spin the rotor with your hand: it should spin freely. If it does not, check your wiring as this is often caused by a wire in the wrong place when connecting in Delta.

Attach the top fairing using the 3 self-tapping screws into the plastic.

If you ever strip the plastic simply rotate the top fairing and screw into new plastic.



Once the fairing is in position, you have completed the assembly of the PowerSpout LH. Well done!

You can skip some parts of this manual and start reading again at section 3.14.

At this stage you might want to remove the fairing and double check you tightened all the parts correctly. Also the propeller still needs to be correctly tightened.

3.8. External lubrication assembly (Sub 06 - LH Pro)

Customers that purchased a PowerSpout LH may ignore this section.

Locate these parts



LH Pro models are supplied with an automatic lubricator as standard. Manual lubrication is still possible by removing the lubricator cartridge and fitting the grease nipple provided. Charge the bearings manually prior to activating the grease can.

These parts will be attached after the body fairing has been installed. This is documented later.

Sub 6	External lubrication assembly (LH Pro & Pro +)	Material	Qty
LH060	68 1/4 x 1/8 compression male connector kit	Brass	2
LH061	BU24L 1/4 bulkhead union	Brass	1
LH062	Back nut for bulk head union	Brass	1
LH063	Nylon 11 1/4 black line tube 125mm long	Nylon	1
LH064	Grease nipple (supplied for LH also)	Steel	1
LH065	Grease cartridge and activator disc	Plastic/Grease	1
LH066	Nipple to grease can adaptor	Brass	1

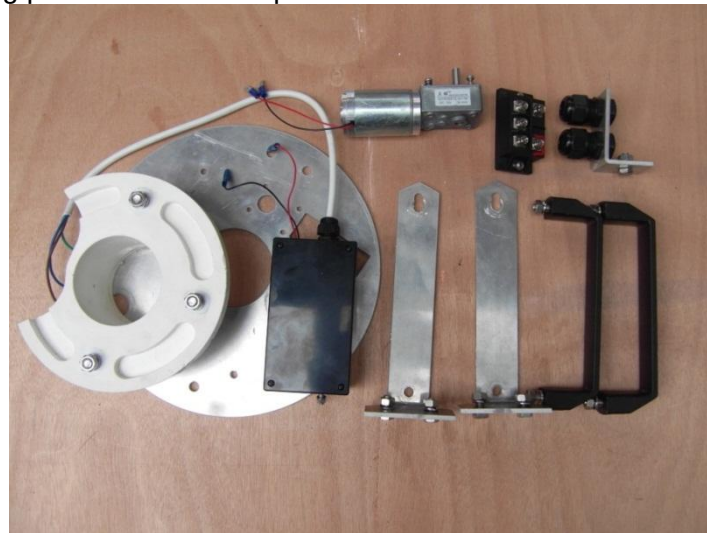
3.9. Auto cleaner drive system assembly (Sub 07 - LH Pro)

Customers that purchased a PowerSpout LH may ignore this section.

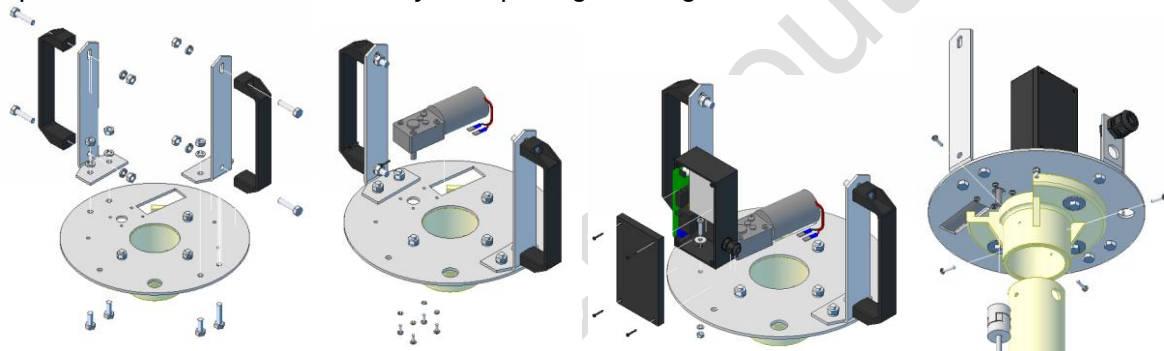
The automatic cleaner will greatly reduce (and may completely eliminate) the need for any manual cleaning of the guide vanes. The automatic cleaner option is highly recommended unless you have very clean water. All LH models have a propeller bar cleaner installed as standard; this will keep the propeller from fouling which is important because this part is difficult and potentially dangerous to hand clean.

Although it is possible to upgrade an LH to an LH Pro, this will be much more costly than if the auto cleaner was purchased on the product to start with.

Locate the following parts shown in the picture and table below.



Exploded views below will assist you in putting it all together



Sub 7	Auto cleaner drive system (LH Pro)		
LH070	D284mm motor mounting disc	Aluminium	1
LH071	Handle inner support bracket and M8 x 20mm fixings (bolt, nut, split washer)	Aluminium/stainless	2 sets
LH072	Handles and mounting fixings M8 x 20mm fixings (bolt, nut, split washer)	Aluminium/stainless	2 sets
LH073	75mm middle flange with cut out with 4 self tapping fixings	PVC/stainless	1
LH074	M8 bolt x 35mm (flange to upper disc, bolt, panel washer, split washer, nut,).	Stainless Steel	3
LH075	Motor timer and power supply assembly in black box	Electrical	1
LH076	Geared motor driver with M4 fixings and split washers	Various	1
LH077	Cable support bracket and M8 x 20mm fixing (bolt and split washer)	Aluminium	1
LH078	Cable glands (only one gland is normally needed)	Plastic	1 set
LH079	Rectifier (LH Pro only)	Electrical	1



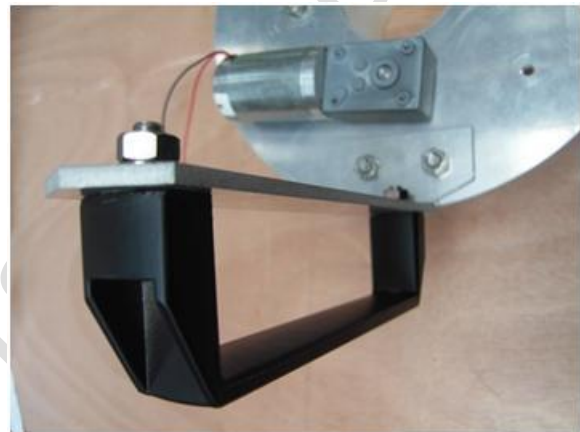
Attach PVC flange to aluminium disc as shown, at this stage leave all fixings finger tight only



Rear View



Attach drive motor as shown



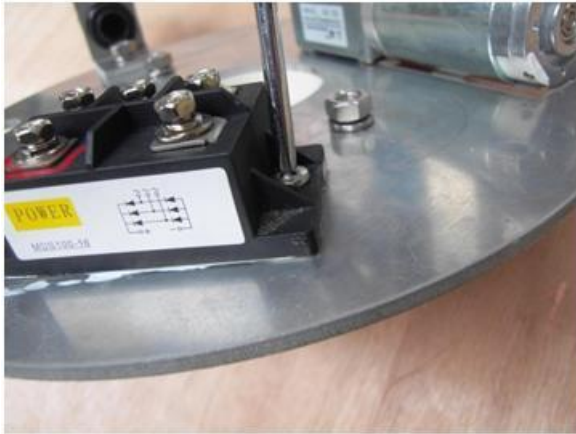
Attach handle brackets and handles as shown



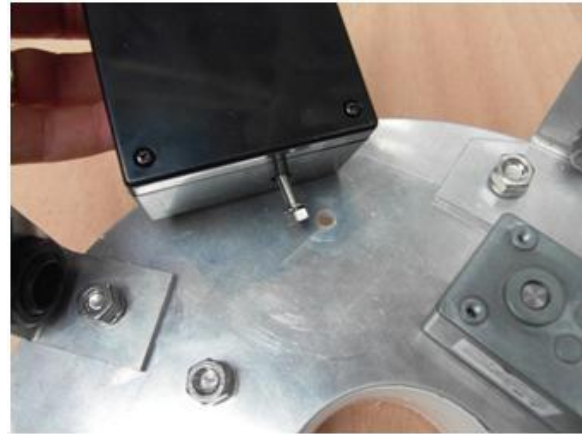
Attach cable support bracket and glands, only the upper cable gland is normally needed. The 2nd gland is reserved for a possible future product variant. Your LH Pro may have a bracket with only 1 fitted.



Smear a thin layer of heat transfer compound on the base of the rectifier. (Some paste is supplied with your turbine)

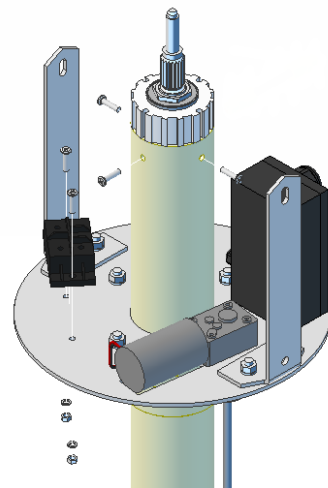
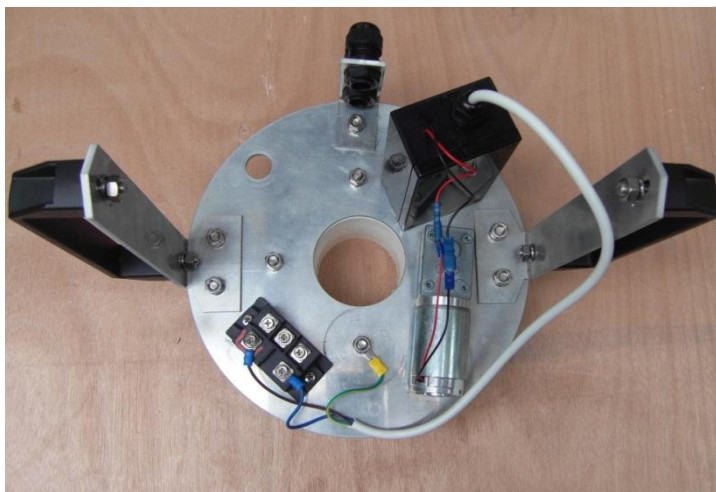


Position the rectifier as shown and fully tighten the M5 rectifier fixings.



Install the black box as shown and fully tighten the M5 fixing.

Your LH Pro sub assembly 07 should look like this, once you have connected the wires as shown.

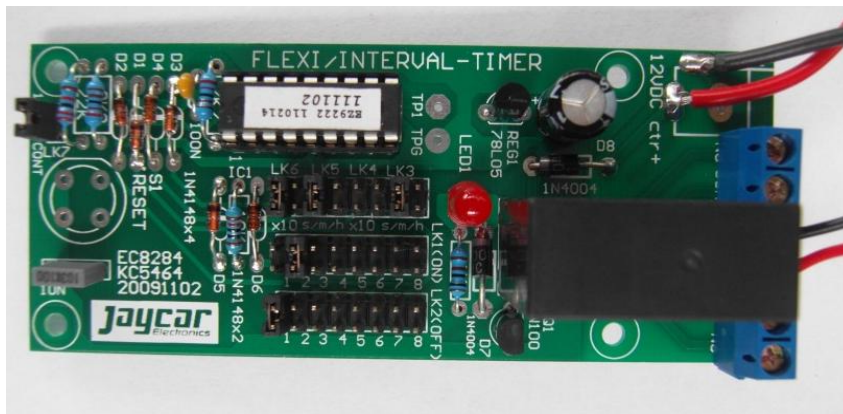


Generally wires for positive connections are red or brown, and for negative connections black or blue wires are used. Note the earth connection point on the M8 fixing. This earth point is for all the metal work in the turbine.

Some power (up to 15 Watts peak) is taken from the DC side of the system to power a DC/DC converter. This converter can take any voltage from 50-400 V DC (so suits all models and voltages offered) and converts it to 12 V DC. This 12 V DC is used to operate a delay timer (that can be adjusted on site if needed) and cleaner motor. All units shipped come set for 2 minutes on followed by 10 minutes off. Do not set the cleaner to run more often as the DC brushes in the drive motor will wear out more quickly. Setting a longer waiting period will increase the life of the motor and may be done depending on the debris burden at your site.

3.9.1. Motor timer

The timer module is used to start and stop the automatic cleaner in the LH Pro and looks like the picture below.



The link LK1 (ON) 1-8 sets the ON time,
LK3 sets the ON time units seconds/minutes/hours (s/m/h),
LK4 sets a x10 multiplier if the link is inserted.

The link LK2 (OFF) 1-8 sets the OFF time,
LK5 sets the OFF time units seconds/minutes/hours (s/m/h),
LK6 sets a x10 multiplier if the link is inserted. Standard timer module

The above picture has ON settings LK1 set to 2, LK3 set to m – this means that on power up the motor will run for 2 minutes.

The above picture has OFF settings LK2 set to 1, LK5 set to m and LK6 set to x10 – this means that following the 2 minute on period the motor will turn off for 10 minutes.

By altering the link positions you can alter the on/off period to suit your needs for automatic cleaning. You must not drive the cleaner for more than 2 minutes in every 12 minutes or the life of the cleaner motor will be reduced.

If the cleaner gets jammed on a stick then provided the obstruction is removed within a day there will be no damage to the relay/motor. Once a jam occurs the timer will pulse the motor on/off every second until it the jam is removed. A jam will result in loss of power as leaves will wrap around the guide vanes and the flow through the turbine will reduce. An observant owner will spot this issue as the Watts displayed on your meter will start reducing and water in the supply flume will tend overflow the sides.

Both the timer module and the DC/DC power supply fit inside a standard plastic housing for protection. Note the insulation between the 2 parts.

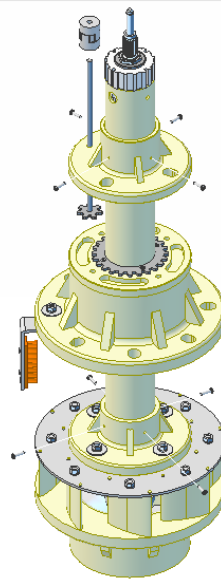
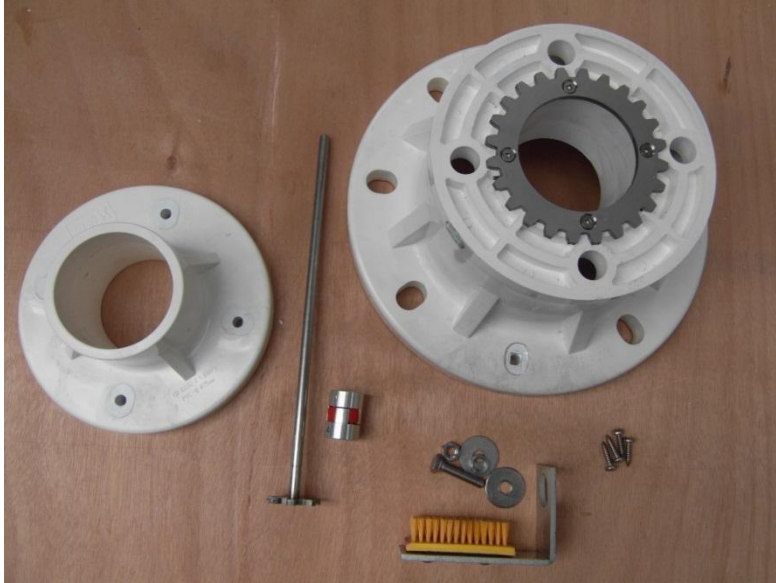
Put this assembly aside for now and start on the Cleaner sub assembly 08 that follows.



3.10. Cleaner assembly (Sub 08 - LH Pro)

Customers that purchased a PowerSpout LH may ignore this section.

Locate the following parts shown in the picture and table below.



Sub 8	Cleaner assembly (LH Pro)		
LH080	8mm alignment coupling	Aluminium/Plastic	1
LH081	8mm drive shaft with gear attached	Stainless Steel	1
LH082	Cleaner rotator with large gear attached	PVC/Stainless Steel	1
LH083	75mm cleaner flange retainer	PVC	1
LH084	Self tapping fixings (flange to outer shaft)	Stainless Steel	4
LH085	Cleaner brush holder and M8 fixing (bolt, panel washers, split washer and nut)	Aluminium/Stainless Steel	1 set
LH086	Cleaner brush and packer	Plastic	1 set
LH087	Cleaner brush self tapping fixings	Stainless Steel	2



Assemble parts as shown, and use a hex key to tighten the coupling on the end of the 8mm drive shaft as shown. Anti-seize compound on the thread of the hex fixing would be wise to assist in removing this part in the future.

Note there are 4 x 8mm bush holes in the PVC flange that can be used. The spare ones can be used in the future to allow for wear. Change the bush position every time you replace the main turbine bearings.

Install the sweeper arm and fixing as shown, note it locates on a plastic bush that protrudes from the PVC flange to prevent rotation and accurate position. Note the cleaner brush should also be replaced every time you replace the main turbine bearings.



Lightly grease the parts to be assembled on the contact surfaces. This is to provide initial "bedding in" lubrication. Once running, water will provide the lubrication needed after the "bedding in" period.

Slide the larger PVC flange assembly over the parts previously assembled. Follow this with the smaller flange as shown in the picture.

Next drill 4 x 3.5mm (1/8) holes through the pipe for the self-tapping fixings as you have already done before. Please note there may already be holes from when the turbine was assembled in our production facility, do not try to line up these holes, it is easier just to drill a new ones.

These 4 fixings lock the stationary smaller PVC flange in place and prevent the large PVC flange from being able to rock, this keeps the gears correctly aligned. Once you have completed this step turn the larger flange by hand to check it is free to rotate. You will notice increased resistance as the brush sweeps the guide vane edge. The correct sweeper direction is anti-clockwise.

Remove one half of the coupling from the above assembly and attach this half to the motor drive shaft assembly as shown and tighten with hex key.



Lower the above assembly over the top of the PVC tube. Align the 2 coupling halves and press together as shown.



Rotate the upper aluminium plate until the 8mm stainless steel drive shaft is parallel to the main PVC tube. **This is very important!**

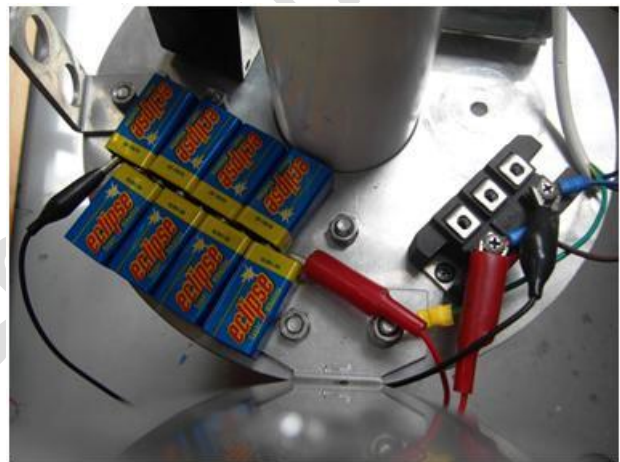
Next drill 4 x 3.5mm (1/8) holes through the pipe for the self-tapping fixings as you have already done before. Please note there may already be holes from when the turbine was assembled in our production facility, do not try to line up these holes, it is easier just to drill a new ones.

Attach the 4 fixings as shown.

You can now test the motor by applying a voltage > 50 VDC to the 2 DC terminals on the rectifier block.

(You can use 8 small 9 V batteries clipped together in series to do this if you do not have a DC power supply on hand as shown).

Make sure you connect the battery polarity correctly or it will not work. If you have problems remove the rectifier from the circuit. Less the 8 x 9V batteries may not work well as the power rating may be too low.



On power up the motor should run for 2 minutes, and then stop for 10 minutes. Check this works and the cleaner runs smoothly, since any problems are much easier to solve on the bench than in the field.

If the sweeper arm turns clockwise, check the polarity of the power supply you are using; if you swap over the 2 wires to the motor it will reverse the direction.

If the rotator operation is jerky or prone to stall check:

- You lubricated all the mating surfaces with grease prior to assembly
- Aligned the stainless drive shaft to be parallel with the PVC tube
- The voltage on the pins on the rectifier is above 50 V DC when operating.
- Your power supply can deliver > 20 Watts at > 50 volts
- The direction is anticlockwise.
- The coupling is not slipping on the shaft; if it is check you tightened the coupling correctly to the specified torque.

Congratulations you have completed this part of the installation for the LH Pro and at this stage should look like this picture.



3.11. Installing the fairing, output lead and lubricator in LH Pro

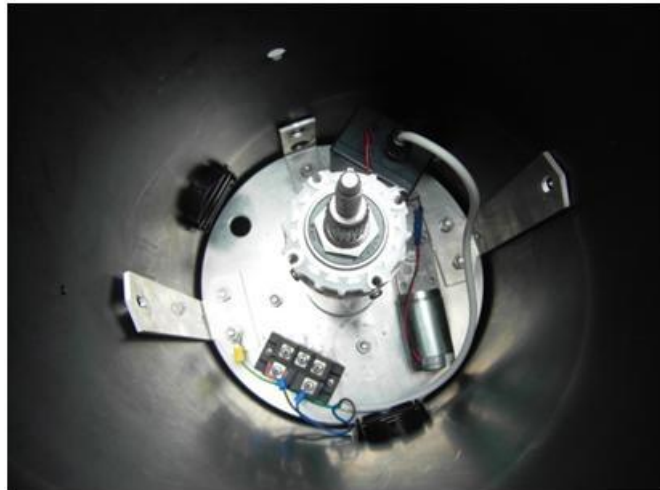


Remove the handles and cables glands from the installed parts so far.

Slide the body fairing over the top of the turbine as shown and it will rest on the sweeper arm. It is possible to put in on upside down. The bottom end has a small return on in the inside edge to stiffen it.

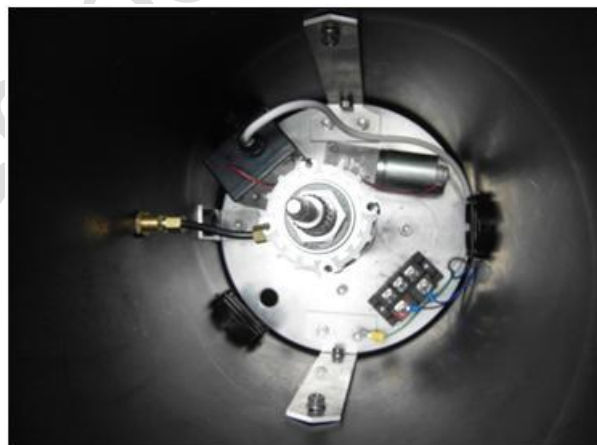
Rotate the body fairing until the holes line up.

Reconnect the handles and cable gland.



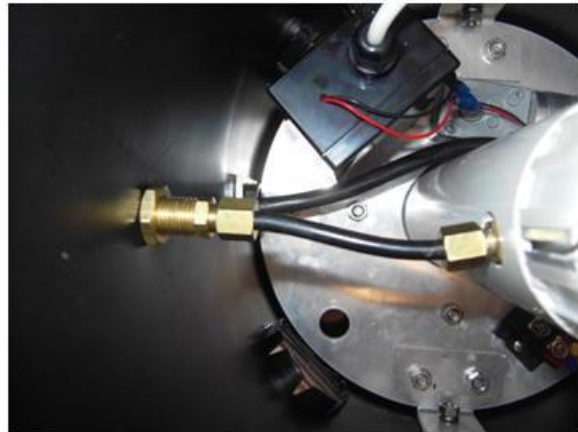
Install the output DC cable; 2m of cable is supplied and your electrical contractor will have to put in a junction box to connect to your main transmission line. Note that for easy removal and for future servicing, cleaning or in the event of severe flooding conditions the ability to remove the turbine quickly is a big advantage. Any plug connection will have to comply with local rules for DC plugs. To avoid any possible confusion with other common plug types, please consult your local electrical contractor for advice on a suitable plug connector for your country and this DC application.

Once complete it should look like this



Close up view of rectifier wiring once generator and output lead is fitted. Connect the wires as shown; closer specific details follow so do this carefully.

Close up view of lubrication system connections. Note a longer length of grease tube is provided in case these 2 fittings end up 180 degrees apart, which is possible.



You can now connect the outgoing cable and generator wires, as detailed below to avoid errors.

Negative Connection

Output negative, 2 wires connected:

- *Negative to black box*
- *Negative to outgoing lead*

3 AC connections

These connections can be either Star or Delta, refer to the LH Pro section that follows to determine if a Star or Delta connection applies to you.

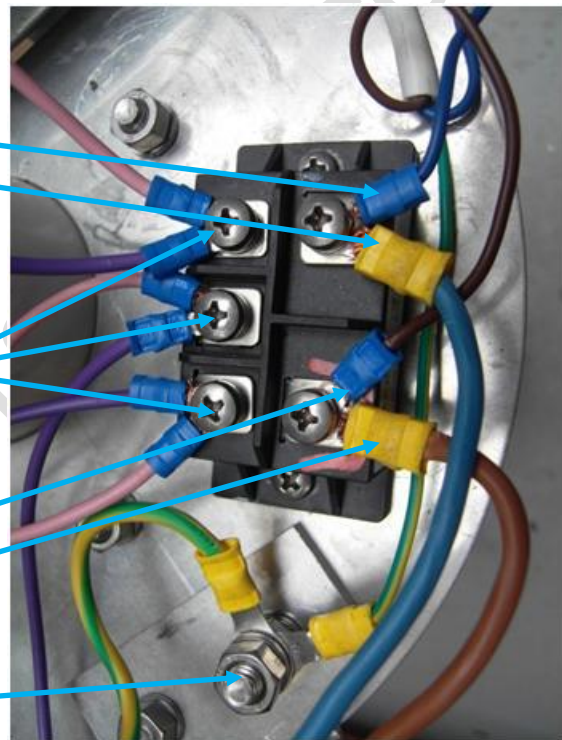
Positive Connection

Output positive, 2 wires connected:

- *Positive to black box*
- *Positive to outgoing lead*

Earth Connection

Earth connections: one from outgoing cable, one from black box.



3.12. Final connections - LH (where relevant) and LH Pro

At this stage tidy up the wiring with cable ties and split loom tube as required. 1m of 10mm split loom tube and 6 cable ties are provided for this purpose. Have your electrical contractor check your work to date and your wiring for you. No wires should be able to touch on metal parts unless protected in loom tube.

Also, as you want your turbine to last for many years, protecting wires on the LH and LH Pro with Petrolatum tape over the terminals of the rectifier will help protect from water ingress. Turbines are often mounted in wet warm environments, ideal conditions for corrosion to take hold.

Every time the bearings are replaced, carefully check all wires and replace/repair if any damage can be seen. Having a qualified electrical practitioner inspect the wiring would also be good advice, every time bearings are replaced.



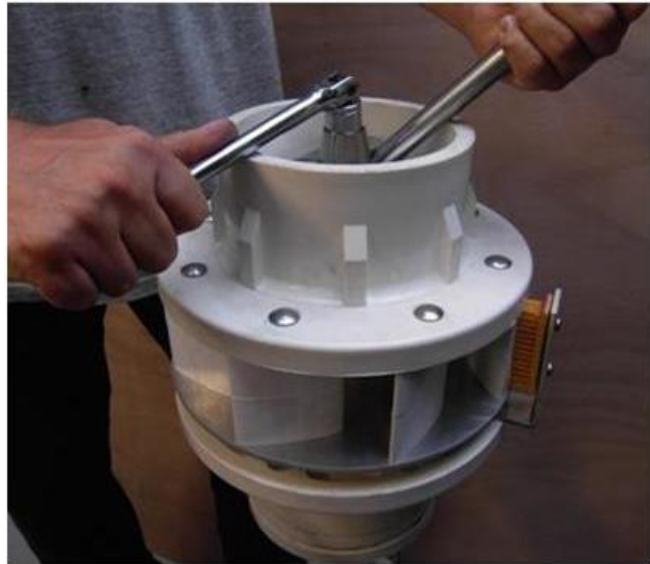
LH Pro with wire protection installed. No wires over 12 V DC are able to touch metal parts unless protected in loom tube.

Note a piece of petrolatum tape on the rectifier terminals.

3.13. Tightening the propeller fixing - both versions

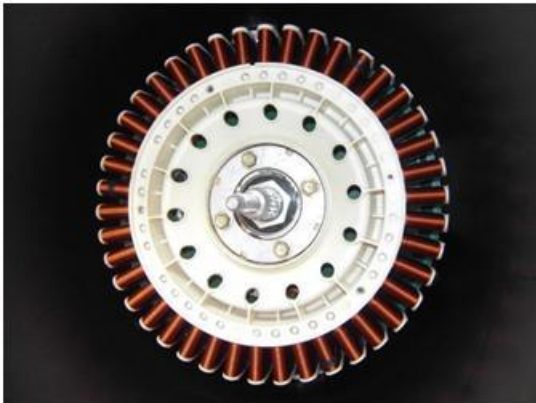
Using a bar through the blades and guide vane as shown, tighten the propeller bolt with a socket as shown.

If you forget to do this your propeller will be pulled off the shaft by the negative pressure below the turbine.

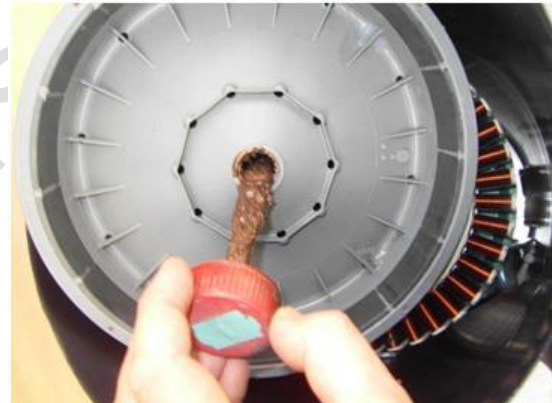


3.14. Attaching the Rotor and body fairing - LH Pro (and LH)

(PowerSpout LH clients should still read this section)



When all done fix the stator in position (large washer on both sides) and tighten the 4 fixings shown.



Apply anti-seize to splines



Also attach the rotor. Wiggle the knob on the rotor to engage the thread and turn the knob clockwise until rotor is fully engaged. Only tighten this knob with the fingers of one hand. Using anti-seize or grease on the spline mating surfaces will make it easy to take apart in the future.

If you have not already done so install the automatic grease lubricator can. Do not activate it yet. It is shown in the picture for completeness, but we recommend you remove it until the turbine has been successfully commissioned; this avoids the risk of accidentally snapping it off while positioning the turbine.

Position the top lid

Install the top cap as shown, rotate the lid to the position shown and attached with the 2 stainless screws. These are positioned at the base of the lid directly in line with the handles.

These screws are to ensure the lid cannot be removed by inquisitive children, exposing them a rotational hazard. There is a warning label on the top of the lid, heed these warnings at all times.



Once you have assembled the turbine you can then turn your attention to installing the turbines correctly while ensuring your safety, the safety of others and care for the receiving environment. This turbine needs to be correctly installed and formally commissioned for it to work well at your site. Guidance notes follow on how to do this for common applications.

Congratulations on a job well done so far.

3.15. Remaining parts list

The parts below are listed for completeness. If you need to use a 250mm draft tube then you will need to purchase with your turbine a 200-250 pipe adaptor (LH1107) and joiner pipe (LH1108). You may be able to buy these parts locally as the freight cost can be high.

Sub 09	Voltage limiting circuit board (reserved for future product variant)		
Sub 10	Full body Fairing (LH Pro)		
LH1001	Body fairing body and lid	LDPE	1
Sub 11	Optional extras		
LH1101	DC clamp meter	Electrical	1
LH1102	Replacement grease cartridge	Grease/plastic	1
LH1103	Spare bearing set (2 identical bearings)	Steel	1
LH1104	Service parts kit for LH	Various	1 kit
LH1105	Service parts kit for LH Pro	Various	1 kit
LH1106	Draft tube to turbine fitting 200mm (supplied)	PVC	1
LH1107	200-250mm Draft tube fitting adaptor	PVC	1
LH1108	200mm OD PVC pipe 230mm length	PVC	1
Sub 12	Miscellaneous items supplied		
LH1201	1m of 10mm loom tube LH Pro Short length for LH	Plastic	1
LH1202	6 cable ties	Plastic	1
LH1203	Piece of Petrolatum tape		1
LH1204	Over voltage magnetic rotor packing washers	Stainless	3
LH1205	Spare fixings, M8 x 35mm bolt, panels washer, split washer, nut Spare self tapping fixings x 2 M5 stare point bolt, split washer, nut	Stainless	1

4. Where and how to site the turbine

4.1. Regulations and good practice guidance

In many jurisdictions around the world electrical work on equipment with operating voltages over 50 V AC and 75 V DC must be carried out by a registered electrical worker. The voltage limits are defined as the maximum voltage across any two points in the system.

A system operating with balanced DC, which is +60 and -60 V DC relative to ground, has a maximum potential of 120 V and is at the limit of unregistered electrical work in NZ and Australia. Most of Europe is 75 VDC. This limit is often referred to as the ELV (extra low voltage).

PowerSpout LH turbines do not meet these requirements for unregistered electrical workers (other than in NZ and Australia for models with a maximum voltage less than 120 vdc). You must ensure that an electrician, who is also a registered electrical worker, completes your installation and commissioning. In many cases you can install the equipment yourself and then have the electrician complete the final hookup, commissioning and turn on, but you should talk to your electrician before you start. The electrician will be responsible for your workmanship and may be reluctant to certify your workmanship, which may not be accessible after the work has started.

4.2. Siting your PowerSpout LH turbine

Some tips for locating a good site for your turbine include:

- Choose a place that is accessible. If necessary make steps and put in rope handrails to ensure that your turbine can be accessed safely.
- Choose a site where the river drops 2 - 5 m quickly (over a set of rapids).
- Place it as close to your battery bank or point of grid connection as possible.
- Hydro turbines do make some noise, so keep them at least 30 m from your home. LH turbines are much quieter than Pelton or Turgo turbines.
- Ensure turbine is mounted above maximum river flood level.

The distance between your turbine and batteries has a significant bearing upon the cable size required. To keep cable size (and hence cost¹) down we usually recommend a cable voltage in the range 70-120V DC for the LH & LH Pro. Turbine sites up to 1,000 m away are often economically viable using 2-core aluminium cable.

4.2.1. Cable sizing

The Advanced Calculator on the www.powerspout.com web site will work out the cable size for you for a given % loss or the % loss for a given cable size.

Try to keep losses as low as possible, particularly if you have limited hydro generation and need all the power you can get. A loss of 5% in cables is normal. Cables with losses greater than 10% should only be used in cases where the cable cost is very significant in the total equipment cost and/or where you can generate plenty of power (more than needed).

¹ EcoInnovation holds considerable stocks of cable at very good prices for our NZ customers

4.3. Water diversion and return

Micro-hydro systems may potentially affect:

- Plants and fish in the water.
- Plants and animals beside the water.
- Stream banks and surrounding land.

You must check with your local authorities to see if you need to obtain consent either to build any structures or to take/return water from a waterway. The impact of your system on stream ecology will usually be considered during this process. Ecolnnovation have some consent application examples for NZ that we can email you that might help in your application.

Diverting less than 50% of the minimum seasonal flow rate in your water source means there is no impediment to fish moving up or down stream and hence gives aquatic life a better chance to survive.

Natural waterfalls and steep rapids often prevent the free upstream movement of aquatic life, as such turbines that exploit natural waterfalls may take more water and do not need to provide fish passage.

Where the fall is engineered from pipes or timber flume the natural bed of the river becomes the best fish pass possible, but you must leave some water remaining in the river bed.

You should take care to ensure that the exhaust water from the turbine can return to the river without scouring the bank or bed of your waterway. Where the exhaust water from the draft tube impacts the river bed, line the river bed with timber/concrete (this is illustrated later in the manual).

Numerous studies have shown that small fish can pass through Kaplan/Propeller turbines unharmed. Kill rates typically range from under 5% to approximately 20% if instantaneous pressure changes are less than 4m.

It is not possible to completely screen small fish from entering the LH turbine; if you did the screen would block very quickly stopping any generation.

4.4. Pipes and flumes

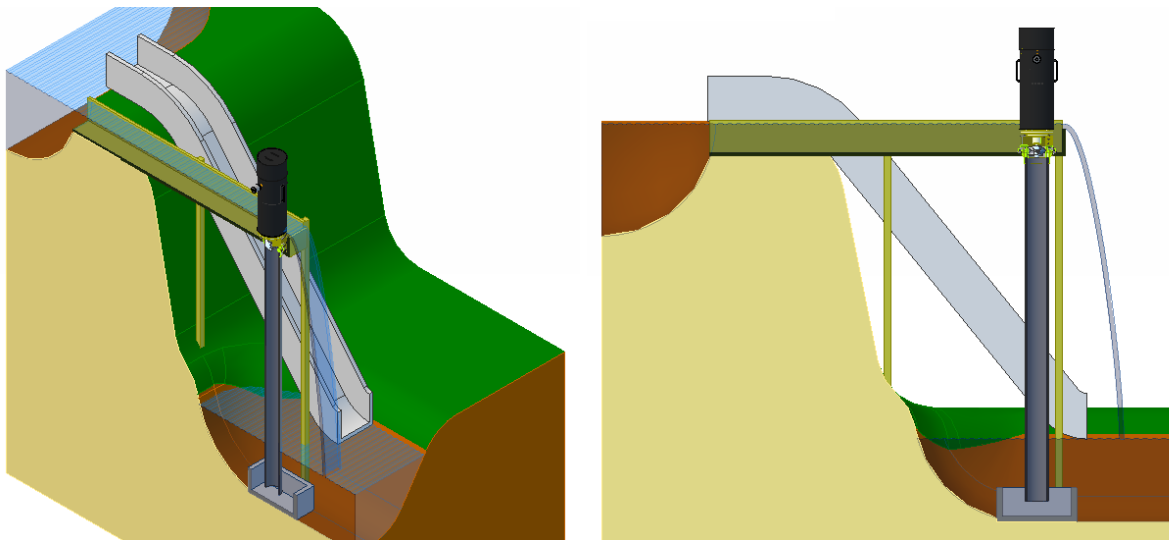


Figure 4. Typical installation of LH turbines

Figure 4 illustrates:

- Timber flume (normally plastic-lined) to supply water to draft and attain the fall needed
- Flume overflow path for excess water and fish pass
- PowerSpout LH Pro turbine
- Vertical draft tube
- Erosion protection at the end of the draft tube
- Bypass for flood flows - could be the natural river bed or an engineered structure or both.

Wooden flumes or PVC pipes can be used to channel the water to the turbine. The flow rate is related to the slope (incline) and dimensions of the flume and the depth of the water in it.

The tables below provide examples of the flow rate in flumes and pipes with rectangular and circular cross-sections respectively. In each case there is a slight slope with a fall of 1mm per metre (1,000 mm) of watercourse.

The minimum dimensions of the side of the flume should be no less than 450mm wide and 400mm high to enable sufficient room to install a single turbine.

Table 3. Flow rate (l/s) for different rectangle flumes with a fall of 1 in 1000

Water Depth (m)	Width of flume (m)			
	0.45	0.6	0.75	0.9
0.2	63	92	122	152
0.3	108	161	215	272
0.4	156	234	317	405
0.5	-	311	425	545

Table 4. Flow rate (l/s) for different pipes with a fall of 1 in 1000

Water Depth (m)	Pipe Diameter (m)			
	0.3	0.4	0.5	0.6
0.2	31	43	52	60
0.3	40	78	104	126
0.4	-	86	152	198
0.5	-	-	155	256

4.4.1. Advice on fixing the flume/pipe to the top of the fall

Where you have a natural set of rapids in a stream you generally have a hard rock river bed to work from. You can connect the flume into the bed of the river at the top of the falls during periods of very low river flows and/or by using sand bags to divert the flowing water around the work site. This is normally done with a combination of rock anchors and concrete. Advice on site from an experienced engineer is often helpful and well worth the consultation fees.

Protection from floods needs to be carefully considered on a site by site basis. The main ways to minimise flood risks include:

- Understand the flooding risks at your site by asking the locals and being observant during heavy rains
- Have the take off to one side of the river
- Do not restrict the flood path with the intake point of your take off; this would increase the flood height
- Use plenty of steel and concrete as needed
- Seek professional advice, particularly on difficult sites
- Always do a 1st rate job, do not cut costs or you will regret it
- Inspect the site after flood events and repair any damage as soon as possible.

The above is easier said than done and the task should not be underestimated. Many sites for Low Head turbines already exist, such as abandoned water wheel sites. Such sites may already have water being diverted into the flume. It is likely that abandoned waterwheel site or sites that have natural falls will be the main application for the LH turbine. If you are installing a flume at a site with natural rapids to attain a vertical fall you need to give due regard to the following:

- Flume size and fall
- Flume entry height
- Mechanism for limiting flow in flume (normally end and side flume overspill is employed)
- Mechanism to stop the flow of water
- Flume attachment at water take-off point
- Flume strength/design and support (often on rammed timber or steel posts)
- Flume lateral and longitudinal stability: you have many tonnes of top weight and good support is needed to prevent flume from falling over
- Flume strength/integrity in floods
- Screen to catch larger debris (sticks and twigs) in a position that can be easily cleaned. A finer intake screen is needed for the LH turbine without automatic cleaner.
- Designed to deter children from accessing or playing on it
- Safe and restricted access to the turbines for service and cleaning
- Large “danger” warning sign and physical barrier in the river before the intake so recreational river users do not get drawn into the intake

Water intake pipes capable of 50 l/s and more can be dangerous and easily capable of sucking a small child into them which could be fatal. Open timber flumes are safer in this regard but good signage and protection are essential, even on private lands. Intakes need to be protected by metal rails to ensure such accidents do not happen.

Many Low Head turbines are installed on the overflow of small lakes or dams and may only operate during the wetter months, with solar PV providing the power during the sunny

months. Installation on dams and lakes is generally easier as the maximum flood height is often much less.

Avoid the many streams (e.g. in New Zealand) that increase 3-6 m in height in extreme floods. Maximum flood height should be less than 50% of the draft tube length.

The following pictures illustrate several aspects at an install on an old duck shooting pond:

Concrete intake barrier connected to a PVC pipe (under the road crossing) then to a 20m timber flume to the get the fall required.



Primary flood path using the original river bed route and weir to control pond height. Note adjustable wood section to alter height for fine tuning. This flood path has no residual flow most of the time but it is very steep and no fish could navigate it. This site was checked by the local regional council prior to installing hydro equipment and it was determined not to require a permit.

Secondary flood path employing a concrete overflow road section over the top of the dam





Timber flume on other side of road.

This site has a recorded minimum drought flow of 4 l/s and estimate maximum flood flows of 2000 l/s. It will flow over 50 l/s for 2-3 months of the year, normally when generation from solar PV is minimal. This site has been used as a test site to develop the PowerSpout Low head range of water turbines.

4.5. Sizing of a vertical draft tube

PowerSpout Low Head turbines have been designed to use 200 or 250 mm OD thin wall (5 mm) PVC pipes for the draft tube. These pipes are commonly used for storm water, waste water and culvert pipes in metric countries. Hence these are not supplied with the turbines. A 200 mm PVC pipe flange is supplied with each turbine and a 200-250 mm pipe adaptor and pipe joining sleeve can be supplied for an extra charge.

Once the length of the draft tube gets longer than 2.6m we recommend that you install the larger 250mm size. The larger pipe will give better results at all sites, but is more costly to do. For example, a 2.6 m head site using 200 mm OD vertical draft tube can generate >524 W from 40 l/s, with about 40 W (7%) lost to the kinetic flow needed for the exhaust water to exit the flume pipe. If a 250 mm OD pipe is installed then this loss reduces to 16 W (3%) and generation will increase to >548 W (a saving of 24 W = 210 kWhrs/year).

A larger pipe slows the water so there is less kinetic energy lost in the slower moving exhaust flow.

4.5.1. Draft sizes in the USA and countries that use schedule 40 PVC pipe

Metric OD pipe sizes are not commonly available in the USA so 'schedule 40' PVC pipe should be used.

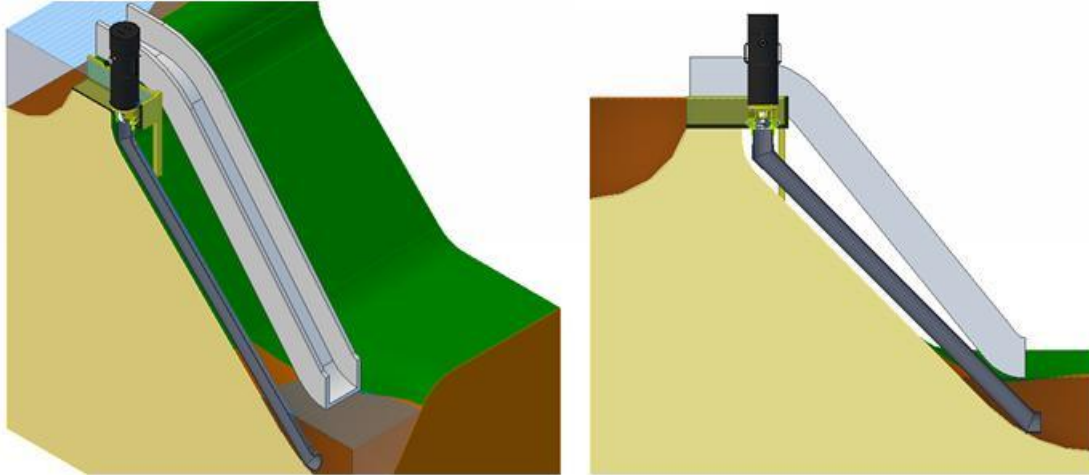
The 8" PVC pipe has an ID in the flared glue end of 219 mm. The 200 mm standard pipe flange supplied with the turbine we machine to 219 mm OD (200mm ID) for these parts to glue together.

If the larger draft tube is needed then the OD of the 200-250 mm pipe adaptor is 273 mm and a flared end 10" pipe is also 273 OD, so these parts will glue together well.

Clients using schedule 40 pipe should advise the pipe ID and OD of both the flared and non flared pipe ends so we can ensure that the pipe flange sent is a good fit.

Schedule 40 PVC pipe sizes				
Nominal pipe size Inches	O.D. Inches	O.D. mm	I.D. Inches	ID mm
8	8.63	219.08	7.94	201.73
10	10.75	273.05	9.98	253.39

4.5.2. Angled draft tube sites



The above illustrates another possible install situation. If an angled draft tube is used then it is longer and therefore has a greater friction loss. The output power can still be estimated from performance table 6.

At our test site we installed an angled drive tube as shown just to test the concept. This comprised 8m of 250mm pipe and 2 x 90 degree bends as shown.

This was tested at 3.3m of head and produced 560 W. The flow was reduced due to the extra pipe friction.



On a straight pipe the turbine produces 760 W at 45 l/s. So the difference is 200W. As the angled draft tube is much longer and the bends are equivalent to about 10m of pipe we have less generation due to:

- Reduced flow rate in the pipe
- Increased pipe friction losses
- Losses due to the water exit velocity

If you need to use an angled pipe instead of a flume and vertical draft tube then you should:

- Increase the pipe to the next size up
- Keep the pipe as short as possible
- Have large bends and as few as possible
- Allow for some power loss
- Allow for the fact less water will be used

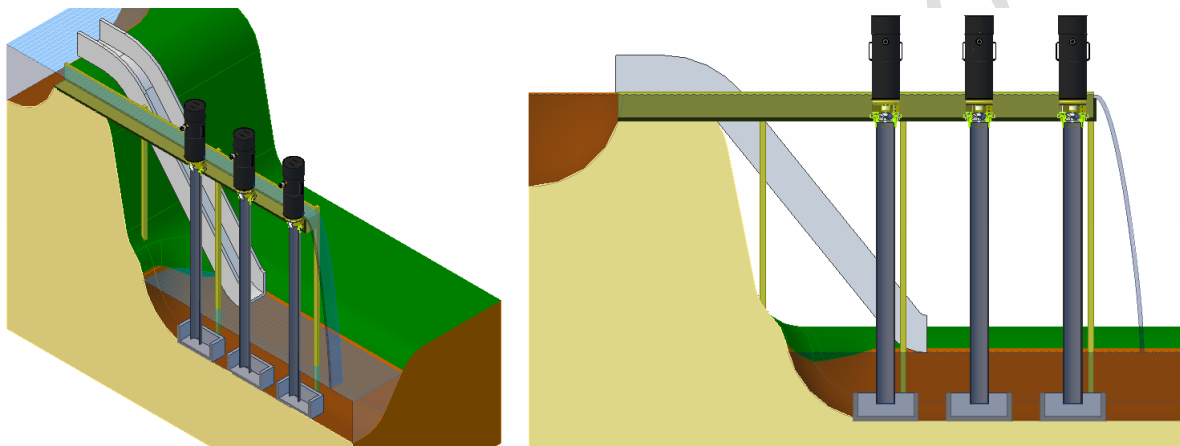
If you do the above output power is likely to be 20-25% less and flow rate 10-15% less than the tables indicate.

You may also find that the turbine will not self-start, and you may need to flick the magnetic rotor by hand to get it going. This is because the longer pipe is harder to fill with water so the negative pressure takes time to build. The stationary propeller inhibits the flow, so a flick of the magnetic rotor by hand will ensure start-up. Be sure to replace the protective fairing.

4.5.3. Does a draft tube need to be tapered

Some suppliers of propeller turbines do supply a gradual tapering draft tube; these are very costly to freight around the world. There is some benefit in a tapering draft tube but it is small and PowerSpout LH turbines still produce more power from the flow despite the use of a parallel sided draft tube. This is the reason we tend to use a larger draft tube size than our competitors.

4.6. Multi-turbine sites



Turbines can be added together as shown. The flume needs to be made larger and stronger and the DC output cable can be combined via a DC fused combiner box into a common supply cable to your MPPT regulator. Some large MPPT regulators can handle 3-4.5 kW of input power per unit. Make sure your MPPT regulator is large enough to handle all the power with a 10% margin.

If your river tends to dry up in summer you simply remove a turbine and block off the draft tube opening.

4.7. Getting access to your turbines

As your turbines might be 2-5 m in the air on top of a flume, you need a safe way to access them. This is best done by using the flume as a walk way. Walking in the water is dangerous as it will get slippery over time and there is a risk of a slipping accident. Also your electrician will not be too happy standing in water with all his test meters.

Removable board walks, about 1.2 m long and up to 500 mm wide, are the way to do it safely. How to do this cost effectively is covered in the guide to flume construction below.

Many jurisdictions around the world require that any fall greater than 1 m has a 1 m high handrail around it and vertical members with a gap no more than 100 mm. As children are excluded from the site the need for verticals <100mm gap may not be needed.

Building a hand rail may not be practical. The use of a safety harness and provision of strong clip on points may be a better way to comply with local safety regulations. We all recognise you can fall off a 3m waterfall and kill yourself, but as soon as you install a platform it needs to be safe for the people allowed to use it. Visitors (invited or not) to your property will be attracted to man-made structures and they have the right to expect them to be safe, even if they have not been invited to try them out.

For the above reason we can only offer guidance notes. You **must seek local advice** and comply with local building codes for any construction you may undertake. A building permit may be required.

Our guidance notes may not be acceptable in many highly regulated jurisdictions. Remember safety first!



This picture shows a clip over flume boardwalk so the turbine can be accessed by walking along the top of the flume.

The position of the walkway board up against the turbine body ensures children cannot reach under and touch the turbine blades.

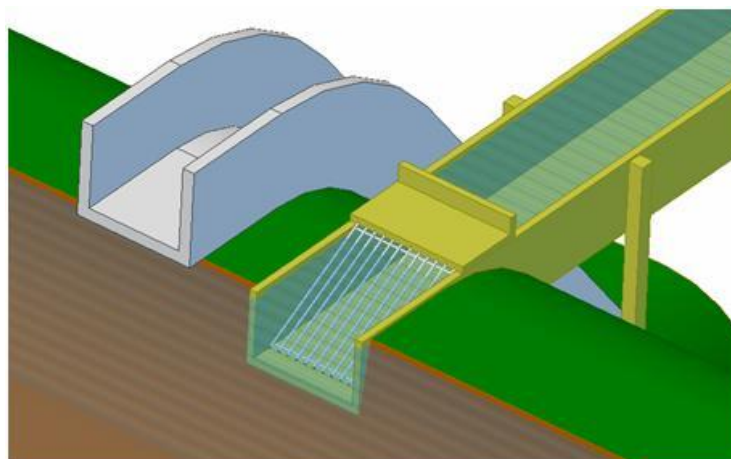
There is no hand rail shown. Fall protection while on the boardwalk is provided via a harness and secure clip on points. Access to the boardwalk is prevented by a locked barrier 1.2m high and a 'Danger Keep Out' sign.

4.8. Making an intake strainer

Angled bars will stop and collect larger debris. The flowing water will tend to push rubbish up onto the flat surface where it is more easily cleaned away.

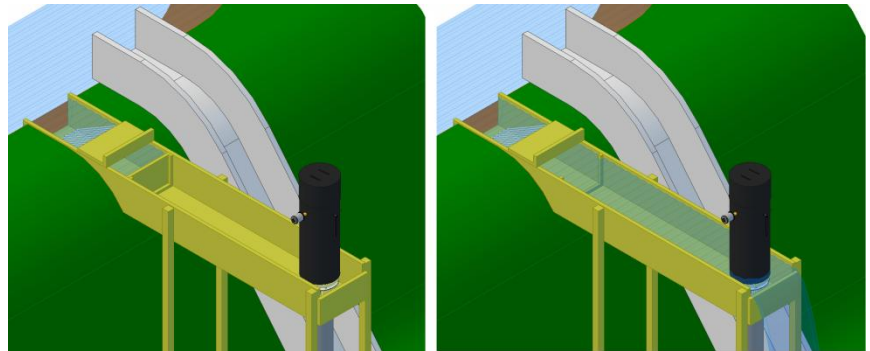
The grate also prevents access from the river/lake by recreational users into the intake flume.

Some on site experimentation will be needed to fine tune the intake design to make it work well on your site and be easy to clean.



4.9. Stopping the water flow

You need to be able to stop the water flow. A simple plywood sheet gate can be used to do this as shown.



4.10. Making a flume – guidance notes only

Reducing waste is always good, so planning your flume to use standard local timber sizes is an important part of good planning. What follows is an example that uses standard materials and produces almost no waste.

In NZ treated pine that has an off ground life >50 years is common. Materials used for garden and landscaping are often a few grades lower than construction premium grade and cost effective. In NZ this is often referred to as fencing grade.

Common fence materials you can buy in NZ include:

- 100x 50 mm x 4.8m long fence rails
- 75 x 50 mm x 4.8m long fence rails
- 50 x 50 mm x 1.2m long fence battens
- 150x 25 mm x 4.8m long boards
- 100 x100 mm post in a range of standard lengths every 600mm up to 3.6m



Always bolt joints with M12 galvanised bolts and 50x50mm square washer; nails are only to hold the material in place while you bolt it.

For a cost effective flume construction set your support posts every 2.4m and 450mm apart from inside edges. River beds are often muddy and difficult to work in. We drove 75mm hot dipped galvanised pipes into the bank until they would go no further; this is hard demanding work only to be done by the physically fit and strong.

We then bolted the timber post to the pipes and straightened them up. By altering the length of the pipe we were able to get 3.6m height using only standard posts without any need to cut them.

Bolt horizontal 100 x 50 members between each post pair to support the bottom flume boards. Make sure you allow for a small fall and get your heights correct.

You will be using 150mm boards (3 wide) to line the bottom of the flume and 3 on each side to give a 450 x 450mm flume section. Stagger the joins every 2.4m so that the joins in neighbouring boards do not line up.

Cut your fence battens in half and every 600mm join the 3 x 150x 25mm boards together using 60-75mm long stainless steel screws.

The flume bottom will be very springy at this stage (do not walk on it yet).

Bolt the side boards in place staggering the joins as before. Using 60-75 mm long stainless steel screws, attach the outer edges of the bottom boards to the side boards every 100 mm to make a beam.

Then join all the side boards together every 600 mm with the battens as before. You can now walk along the flume safely.

The diagonal braces shown are to provide lateral (sideways) restraint, but this may not be sufficient with posts bolted to pipes (consult local engineers). Lateral restraint can be increased by using screw ground anchors and cables to the top on the posts and tightening on opposing sides.

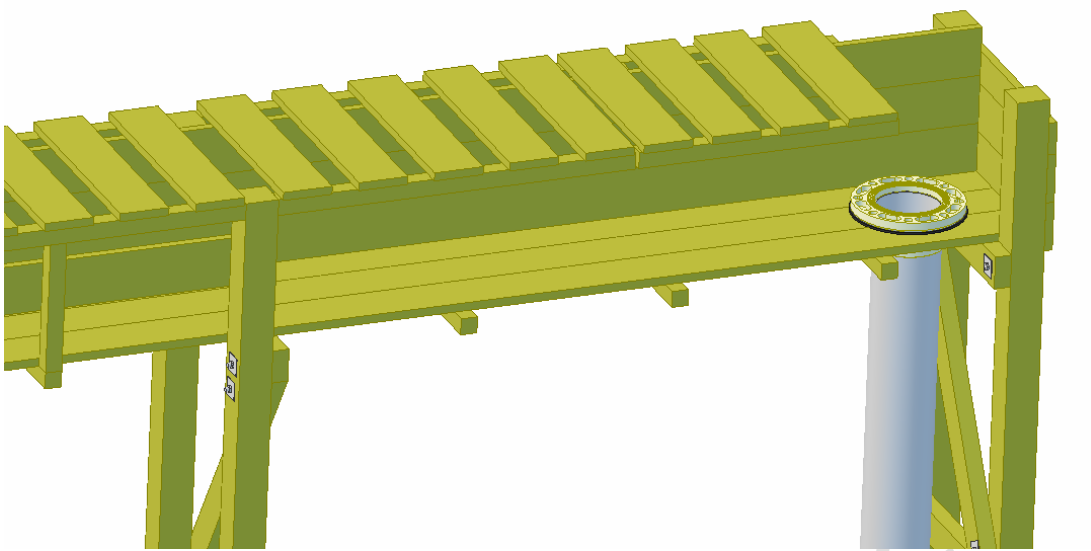
You will also need to provide longitudinal restraint. Bolting diagonal 100x50 opposing timbers between the sets of vertical post will suffice or you can use ground anchors and cables as mentioned before.

The end result needs to be a strong structure that can convey the water and bear the weight of several workers without any tendency to sway.

You can now attach thick UV stable plastic sheet and hold in place thin 10x30mm timber battens which will ensure your flume does not leak.

The last task is to make some firmly fitting board walk sections; these are made from the 50x50 mm battens and 150 x 50 mm boards previously shown. These should be screwed in place at each corner so that if you stand on the edge and it will not flip.





4.11. Installing a vertical draft tube into a timber flume.

In this example the total head water to water level is 3.6m and a 250mm OD PVC draft tube will be installed using the fittings that are available at time of purchase of your PowerSpout LH1500.

Pipes are always purchased locally. Thin walled PVC pipes are commonly used for culverts on farms. In this example a 6m length of 250mm OD PVC pipe was purchased for 200 \$NZ (approx. 150 \$US). This 6m length was almost enough pipe to make 2 draft tubes.

The parts needed:

- Draft tube to turbine fitting 200mm (supplied with turbines)
- 200-250mm Draft tube fitting adaptor (extra not supplied with turbine)
- 200mm OD PVC pipe 230mm length (extra not supplied with turbine)
- 250mm OD pipe of correct length (draft tube buy locally)



Apply PVC cement to both sides as shown and press both parts together; be quick because the parts will fuse quickly. Up to 80kg of force may be needed to push the parts together. Wipe off excess glue with a clean rag.



Repeat the above for the other components as shown



Measure the length of 250mm OD pipe needed accurately and cut to length.



Glue the pipe into position. A large force is needed to push the final join together. You will need several helpers to assist you to do this. Use gravity to aid you.



Mark in the base of your flume a hole the same size as the OD of the pipe adaptor (275mm approx.). The picture shows the plastic lining of the timber flume being cut with a 275mm plate as a guide. Drill 8-10mm start holes for your jig saw blade.



Cut out hole in the timber flume



Apply adhesive foam seal tape or cut an annular ring from foam sheet. A foam sheet camping matt can be a good cheap source for suitable material.



Install draft tube through hole in timber flume



Secure the pipe to the flume with 4-8 stainless steel tech screws.



Check the end of the flume is at least 200mm under the water line.



Secure the flume (note the webbing strap). Run the flume with full flow (no turbine installed). The exhaust water will then dig a hole in the river bed for you. Once sufficient room has been made, make a timber frame that fits in the river bed to protect it from further erosion. When the turbine is installed the exhaust water velocity is greatly reduced.



Normal flow when the turbine is installed.



The turbine shown here is installed and running at 870 Watts, 3.6m head and 47 l/s. The turbine is doing about 1300 rpm.

Note that the water depth is about 300mm, the turbine has all the water it needs to run at full power for the head of the site. Surplus water not needed continues down the flume, over a height control weir and back into the river.

Some fish can escape by this surplus flow route.



This is the same turbine running with about 50-60% of the water needed. The MPPT controller has slowed the propeller speed to stay at the maximum power point, output has dropped to 400 Watts and falling, head has fallen to 3.4m and speed to 800 rpm.

If the flow continues to drop then almost complete loss of generation can be expected.

At flows below 25 l/s either a Pelton or Turgo turbine should be employed so generation can continue down to 5 l/s during prolonged dry spells. This is also the time your solar PV panels will be working well, i.e. dry summer conditions.

A PowerSpout LH1500 turbine can replace a water wheel at a fraction of the price as it has at this site.



5. Cable connections

Earthing of your renewable energy generation system may be required for personal safety and protection of the system from electrical faults. Not all DC systems are earthed and the rules vary from country to country. Systems operating over 120V DC should almost always have an earth connection.

New Zealand electrical regulations allow you to work on systems up to 50 V AC and 120 V DC without qualifications. Outside NZ you need to check your rules to see what you can legally do yourself. Generally the rules in other parts of the world are 50 V AC and 75 V DC without qualifications.

In the USA the National Fire Protection Agency (NFPA) provides wiring rules that are generally adopted by each state. You can access these wiring rules free on line at http://www.nfpa.org/freecodes/free_access_document.asp?id=7005SB. Please also check with your local state authority if you are in the USA, as each state may vary from the NFPA wiring rules.

The 2005 release of the NFPA National Electric Code (NEC) indicates a ground connection is required for all DC power systems in the USA. This is not the case for many other countries, so check if a ground connection is needed.

There is likely to be fewer install problems with the PowerSpout LH turbine, as thy can only be installed via MPPT regulators or grid tied inverters. The PowerSpout LH must not be connected directly to a battery bank but only via a compatible MPPT regulator.

Many home owners attempting to install a renewable energy system themselves for the first time can make some fairly serious errors:

- Connecting a hydro turbine to a solar regulator not designed for a hydro turbine.
- Connecting the hydro turbine polarity in reverse (this normally destroys the rectifier).
- Using a poor quality second hand battery bank with dirty/corroded terminals, which results in the battery not being connected in the system.
- Forgetting to tighten the battery terminal bolts, resulting in the battery bank being disconnected from the systems, result as above.
- Not checking that the regulator has been programmed correctly with your battery setting and tested for correct operation prior to leaving the site.
- Installing a regulator that is too small or one that does not work and not knowing how to determine if the regulator is working.
- Installing a regulator (close to its maximum amp rating) in a tin shed that works most of the time but in summer trips out. You have to de-rate regulators in summer when above 20 degrees Celsius. Such a failure is the result of an incorrect installation environment.
- Installing equipment in a damp/humid environment resulting in corrosion problems.
- Insect infestation in equipment resulting in corrosion damage from insect excrement.
- Bird and rat nests inside and behind cooling fans or inside electrical enclosures resulting in failure and fire hazard. In most cases this would have been avoided if good installation practice had been followed.



Dead mice found inside failed inverter

- Connecting the wire supplied with the PowerSpout turbine in reverse polarity. This will result in the turbine wire fuse blowing and may damage the rectifier in the turbine.

NEVER work on your renewable energy system with the hydro in operation.

Ecolnnovation will not be liable if you connect this equipment incorrectly and in doing so damage other equipment in your system. If you are not skilled then have a suitably qualified professional install the equipment for you. In many countries this is a mandatory requirement.

5.1. PowerSpout LH wiring

The wiring from the PowerSpout LH is very simple: you connect the DC output cable to your transfer cable via a junction box.

This transfer cable is then connected to your MPPT regulator or grid connect inverter via a correctly sized breaker. This breaker should be sized to trip at about 2 x the normal current in the cable. You can determine this breaker size by dividing the Watts you expect to generate by the running voltage in Table 7 and multiplying by 2.

For example: an LH hydro running on 3.6m head will generate about 870 Watts. When ordered it was stated that a Midnight Classic 250 regulator was being used. The generator stator fitted has a running voltage at the peak power point of 98 V approx.

So in this example the breaker should be $(870 / 98) \times 2 = 17.7$ amps, so a 16 or 20 amp breaker should be used. Make sure the breaker is rated for DC amps.

Leave the breaker turned off and complete all the commissioning tests detailed in section 7 before this breaker is closed.

5.2. Batteries

Please refer to “Getting the best from your batteries” in the PowerSpout Pelton Installation Manual.

6. Power meters

It is important that you have a means of permanently displaying the power generated by your hydro turbine. Most MPPT regulators and grid connect inverters do this.

A meter enables you to see any change in the output power, which could indicate a problem that needs your attention, such as:

- Blocked flume screen
- Blocked intake vanes or jammed auto cleaner
- Reducing river levels and available water flows making operation of the turbine no longer practical

Annual output for a continuously running turbine can be calculated as follows.

$$\text{kWh/year} = \text{generation Watts} \times 24 \times 365$$

For example a 500 W (0.5 kW) hydro will generate 4,380 kWh/year

To read amps in the cable you can buy a DC clamp meter (be careful not to buy the cheaper AC clamp meter).

We strongly recommend that any household living off the grid buys a good quality DC clamp meter, and learn how to use it, as this will be very useful in a Renewable Energy (RE) system. We also advise you to learn the difference between volts, amps, Watts and Watt-hours as it is very difficult for installers/advisors to assist over the phone or by email if you confuse these terms. The PowerSpout Pelton Technical Manual has further information and there are numerous websites on this topic.

7. Turbine Commissioning

It is important to formally commission the turbine and associated system to ensure it is working correctly prior to leaving the site for the day, see section 7.1. If you do not have the time to correctly commission your turbine, then do not leave it running. Complete the procedure another day.

Once you are happy that you have successfully commissioned the turbine you should record (see Section 11.2):

- Flow rate through turbine
- Actual operating head (water to water distance)
- Output Watts displayed on meter
- Generator equilibrium temperature
- Picture of installation
- Date for next service check (see Section 8.2)

Once the turbine has been mounted and voltage commissioning checks completed and passed, the power cable connected to the inverter or MPPT regulator you may turn on the turbine.

- Check for current flow to the load.
- Check regulators are working.
- Check you have plenty of water to feed the turbine.
- Check that the delivered Watts is similar to what you were advised after allowing for cable and MPPT regulator/inverter losses.
- Check for erosion/scouring/flume overflow and fix if needed

7.1. Commissioning tests (important!)

All LH turbines are connected directly to electronic controllers such as off grid MPPT regulators and grid connect inverters. You must do the following commissioning tests **prior to hook up**. These test must be done by a qualified electrician and documented as proof they have been done.

- Run the turbine electrically discounted with maximum water flow and head possible and measure the DC voltage on the output terminals.
- To allow for a small ripple in the supply from the 3 phase rectification add 10% to the above value to obtain the maximum voltage.
- Check that this maximum voltage is less than the maximum input voltage approved for your MPPT regulator or grid connect inverter by a margin of at least 10 volts.
- If the maximum voltage is too high, then **do not** hook up the equipment.
- Some generators are fitted with stators that can be connected in star or delta. A delta connection will result in a lower voltage than a star connection. So if wired in star change to delta and repeat the above checks. Should the maximum voltage still be too high contact your supplier. Do not hook up your turbine until you get a valid test as above. A fail means there is a problem that needs to be resolved before you can continue with the commissioning process.

- If the maximum voltage is only just above the rating of the equipment then you can pack the rotor with 1-3 washers to solve the issue.
- You must repeat these tests after a turbine service, as it is easy to forget to replace the packing washers.



No liability for damage to connected electronic equipment is accepted, as if you had correctly done the above checks this could not happen.

7.1.1. Commissioning example

An LH turbine connected on a 3.0m head was supplied with a stator that had the code 100-7S-2P- 6W engraved on the back. The 6 wires from the stator can be connected in star or delta (6W at the end stands for 6 wire version, S = star, D = delta).

The electrician did the above test in star, and recorded that the open circuit voltage (OCV) was 238 VDC. He noted that the client was hooking to an Outback FM60 with a maximum input voltage rating of 150 VDC.

He instantly realized that the voltage was too high. The turbine was reconnected in delta and the tests done again. This time 136 VDC was recorded. He then did the following calculation: maximum voltage = $136 + 10 \text{ ripple} = 146$.

This has to be less than 150 VDC maximum input for an FM60 minus a 10 VDC safety margin. As the safety margin is only 4 VDC, he placed one packer under the magnetic stator and retested the unit. This time he had a safety margin of 12 volts, so was OK to proceed with hook up. Once hooked up the unit ran loaded at the maximum power point at 70 volts with a 3 volt drop on the cable, i.e. 4.2% cable power loss.

The unit ran at 600 W on the display of the FM60. Allowing for 4% FM60 loss and 4.2% cable loss, he calculated that the turbine is generating $600 / (0.96 * 0.958) = 652 \text{ Watts}$. This compared very closely with the published output for the turbine at 3m head and 43 l/s flow rate.

All the above was documented and placed in the system manual folder for future reference.

7.2. Packing out the rotor



Turn knob to optimize, pack with washers and tighten to ensure rotor stays in position set (note 1mm thick stainless steel washer are supplied for packing).

8. Operating your system efficiently

The PowerSpout is a durable machine but it runs 24/7 in a testing environment, so regular checks and maintenance are advised. A PowerSpout LH may do more revolutions in one year than a car engine during the life of the car. A car engine has a filtered and pumped oil lubrication system, whereas a small hydro turbine does not. You must pay special attention to the bearings. A bearing maintenance schedule is outlined below and you are required to follow it if your 2-year warranty is to be honored. Should you have a failure during the 2-year warranty period we will ask to see your log book as proof you have followed the maintenance schedule.

To maintain your hydro scheme in a good condition for years to come we recommend you keep a log book and regularly (every week initially, and once you become familiar with your system every 2 weeks) the following:

- Check the specific gravity of your batteries with a hydrometer and reduce your power usage if battery charge is falling.
- Check the acid level in your batteries and top up with distilled water as required
- Check hydro output is normal and has not changed since last checked.
- Check your diversion load is working if installed on your MPPT regulator.
- Check you have sufficient water flow to run the turbine. If you do not, stop the flow and remove the turbine and place it in dry storage.
- Check there are no obstructions (twigs) that have jammed in the auto-cleaner (if fitted)
- Once a year check termination points on system, battery, regulator, inverter, fuses and diversion load. Clean and tighten as required. If you observe any heat damage or corrosion at terminations attend to these and repair. Remember to turn off all generation, your inverter and remove battery fuses before cleaning/tightening any termination points. You should pay special attention to your diversion load and battery terminals.
- Once a year remove your turbine into a workshop environment and do the following:
 - Remove the body faring and clean off excess grease that may have splatted on it
 - Check the top end bearings for any signs of wear and replace if needed, replacement is recommended every 12 months
 - Clean all components and inspect for wear
 - Replace the propeller fixing bolt with a new one
 - Replace the lower nylon bush
 - Replace the cleaner brush
 - Change the bush position on the 8mm gear drive shaft (if fitted with auto cleaner)
 - Check all wires for any signs of damage from rubbing or heat, repair as needed
 - Reassemble all parts as per manual and lightly grease contacting parts
 - Charge bearing with grease and fit an new automatic grease can if fitted
 - Test operation of the auto cleaner if fitted, the 12v motor drive may wear out after 2-3 years of operation and will need to be replaced with a new one.
 - Prior to reconnection to electronic equipment check the OCV is within upper limit.

We also suggest you are wary of complacency. Since these systems work and give free power, people tend to keep adding more and more loads until they reach the limit of the system. Hence we recommend you:

- Fit a remote power meter to your inverter that will alert you if you exceed your peak load and advise you how many kWhrs you are using each day.
- Tell your guests about living off the grid and that they cannot plug in large resistive heaters, as these can knock years off your battery life and overload your inverter system.



Power meter

8.1. Spare parts

You should consider having the following spare parts on hand, particularly if you live in a remote part of the world:

- Spare bearings and seal (2 x SKF bearings 6005-2Z)
- Spare auto grease cartridge
- Spare cleaner motor

We also supply kits as below to make it easy for you; these kits ship for free if ordered at the same time as you turbine.

LH Pro spare parts kit that includes:

- Bearings
- Spare auto grease cartridge
- Lower nylon bush
- Cleaner brush
- M16 expanding bolt
- 47mm OD shaft seal
- Propeller plastic end cap



LH spare parts kit that includes:

- Bearings
- Lower nylon bush
- M16 expanding bolt
- 47mm OD shaft seal
- Propeller plastic end cap



8.2. Lubricating the bearings

Factory fitted bearings in your PowerSpout LH hydro turbine are top quality SKF explorer series sealed bearings which can last many times longer than low cost bearings in the same application:

- Front and rear SKF 6005-2Z OD 47mm ID 25mm

Sealed bearings do need to be re-greased at times as hydro turbines run 24/7 and see very high cycle rates. The PowerSpout LH is provided with a re-greasing nipple so this can be easily done, you just need to stop the turbine and remove the fairing. The LH Pro has an automatic grease lubricator fitted than needs to be replaced every 12 months.

You should lubricate your PowerSpout LH bearings at the time you first use it and then:

- Every 6 months for generation up to 600 W.
- Every 3 months for generation up to 1500 W.

Good quality grease must be used. We recommend SKF LESA 2 grease for all PowerSpout applications or close equivalent.

http://www.mapro.skf.com/pub/pds/LESA2_datasheet_e.pdf

Pump into the bearing block about 20 mL of grease. This is normally about 20 pumps of a domestic type grease gun. Subsequent re-greasing should be about 5 mL of grease (about 5 pumps).



Remember to grease your new PowerSpout LH

If your turbine is supplied with an automatic greaser you should still manually charge the bearing block with 20mL of grease prior to activating the automatic grease cartridge.

If you turn your turbine off during the dry season or for any period greater than 2 weeks you should lubricate as above prior to turning off.

Turbines that are only used during the wet season should not be fitted with automatic grease cartridges. If you do need to stop your LH Pro turbine for a few months and would like your grease cartridge to slow down (there is no/off once activated) remove it and put it in a plastic bag in the fridge.

In very hot climates grease cartridges may not last 12 months, and in very cold climates they may last up to 2 years.

Remember, your PowerSpout 2-year warranty is conditional on bearing replacement every 12 months (if needed following a documented service check) and the above lubrication regime that you should document in your log book.

9. Safety

We have tried to ensure you can install and operate your PowerSpout with little or no damage to you, others or your environment. You can also contribute to this by ensuring you are aware of the potential hazards that exist when dealing with moving parts, electricity, access to your hydro site, water, and taking steps to help others recognize and avoid such hazards.

9.1. Top cap safety warnings

The top lid of both the LH and LH Pro forms part of an electrical enclosure and carries the following warning signs. There are both rotational and electrical hazards present. Turbines must be turned off and unplugged (or breaker turned off) prior to removing this cover.



- Electrical hazard
- Rotating machinery hazard
- Made in New Zealand identification
- Recycling identification

Once the turbine has been commissioned, all fairings must be in place and secured with the supplied fixings. This precaution ensures that children cannot remove the covers and be exposed to a rotational hazard.

It is possible for a child to insert a hand through the guide vanes, which would result in serious hand injury. The installer must make provisions to ensure this cannot happen such as:

- Grate over the top of the turbines that is locked in place, extending 600 mm each side to ensure a child cannot reach under and touch the blades.

The turbine installer must ensure that the turbine is mounted such that children cannot reach up under the turbine and be able to touch the spinning blade.

9.2. Grid (power network) connections

All PowerSpout LH variants can be grid-tied (no batteries required) this option suits clients that are already connected to the grid and have a good water resource close by.

Figure 3 shows the system configuration for a grid tied PowerSpout using a SunnyBoy inverter from SMA.

WARNING

Operating voltage within a PowerSpout LH Pro is normally around 180-200 V DC when grid connected. Open circuit voltages can be as high as 400 V DC and is much more dangerous than the 230 V AC found in many European countries and must only be installed or serviced by persons trained in electrical work.

Please ensure you use a registered electrical worker who is familiar with this type of equipment and voltages.

10. Troubleshooting

The fault finding procedure here is concerned with only the PowerSpout LH operation. For assistance with your system please contact your equipment installer or provider. The following is designed to locate the majority of possible faults.

If you do not understand the electrical measurements below then please consult your installer or electrical worker for assistance.

If you are concerned your system is not operating correctly then measure the PowerSpout LH Watts and compare with the data supplied with your PowerSpout LH.

If Watts from your PowerSpout is within 10-20% of the design Watts provided for your site then the PowerSpout LH is working correctly and the difference is likely due to: cable losses, MPPT regulator/inverter losses, and small variations in the site data (head and flow).

If the Watts are between 20% and 80% of the design Watts.

- Confirm you have sufficient water and the head you are operating at. If it is the first assessment of your PowerSpout LH installation then also check the accuracy of your water resource information supplied when you ordered your PowerSpout.

If there is no generation check the following

- If output voltage is 0V and current is 0A then check water flow, and that the turbine is spinning and is electrically connected.
- If output voltage is 0V and current is at or above the design current then check electrical connections for a short circuit and correct fault.
- If output voltage is correct and the current is 0A then check and correct electrical connections to MPPT controller or grid tied inverter

11. Site data for hydro required

11.1. PowerSpout Low Head site data

In order to assess your hydro site potential you can either

- Visit our web site www.powerspout.com and complete the Advanced Calculator, or
- Complete the table below and email it to questions@powerspout.com we will reply promptly with the best hydro option available for your site.

Table 5. Hydro site data required for product order/manufacture

	Units	
Head at site (vertical drop/fall of pipe)	m or ft	
Flow available	l/sec or gal/min	
Can a vertical draft tube be installed	Yes / No	
Have you checked that you can buy 200mm and 250mm OD thin walled PVC pipes locally	Yes / No	
If No above then state the inside and outside dimensions of the PVC pipes you can obtain of a similar size. State these dimensions for both the plain and flared ends on the pipe.	Flared end ID mm/Inch	Flared end OD mm/Inch
	Plain end OD mm/Inch	Plain end OD mm/Inch
What is the cable length from turbine to batteries	m or ft	
If cable is installed what size is it	mm ² or AWG	
Do you want us to advise cable size?	Yes / No	
For off grid system state your battery voltage	12/24/48	Volts
For off grid system state which MPPT controller you intend to use		
For grid connect state the make and model of grid-tie inverter you intend to use		

Your turbine will be designed for the site data you supply above. If you operate it on a different site, the output power will differ and not necessarily match the prediction of the advanced calculator. A new generator core may be required to obtain the best results in such cases. LH turbines can only run over a maximum 2:1 variations in flow rate ie it can tolerate a reduction in the flow rate to half the design (maximum) flow. While it will still run, it will produce less than half the power because the head and the turbine efficiency will also have dropped a little. For example, if a turbine is designed to generate 1000 W with 50 l/s and the water flow drops to 25 l/s it will generate approximately:

$$25/50 \times 1000 \times 0.9 = 450 \text{ W}$$

Once flow drops below 50% the MPPT tracker cannot slow the blade sufficiently and air will get drawn in. This means the vacuum will be lost and generation will be minimal if any at all (10-50 Watts).

11.2. Installation details

We recommend you take note of and let us know the final system details (as below) for future reference and to help with ordering replacements or upgrading the system.

We would also like you to let us know your performance data so that we can determine conversion efficiency at your site. This helps us refine our calculations for future clients. As every site is different efficiency will vary slightly from site to site.

Table 6. Hydro installation and performance data

Installation details	
Date installed	
Location of installation	
Draft tube inside diameter	m or inch
Draft tube outside diameter	m or inch
Draft tube length	m or ft
System nominal voltage	V
Cable length	m or ft
Cable wire size (if installed)	mm ² /conductor
Generator name (e.g. 100-14S-1P delta)	100/80/60/60dc - <u> </u> S- <u> </u> P delta/star
MPPT regulator or inverter installed	
Performance data	
Flow rate of water through turbine	l/s or gal/min
Watts delivered	W
Maximum power point operating voltage	V

11.3. Noise

Noise is not normally an issue. All PowerSpout LH turbines are quiet; there will be more noise generated from the flowing water. Our turbine is normally quieter than others as it turns slower and is enclosed. Hence if noise is an issue at your site you should check the following:

- The magnetic rotor turns freely, you have not picked up magnetic debris on the magnets when putting in together
- The bearings have been greased correctly as per the manual
- The bearings are in good condition (likely to be the cause if noise has increased gradually over time)
- The unit is running at the correct speed, it will run fast if your batteries are fully charged or the grid is down. If installed on an off grid battery based system fit a diversion load to turn on once batteries are full, most MPPT regulators have this functionality.

We have not taken noise level readings, as all hydro sites are different and it does not seem to be an issue. That said, some clients have installed turbines too close to their homes.

Generally the higher the output power the more noise from the unit. It sounds like a washing machine in spin from behind a closed door. Vegetation around the turbine will dramatically reduce the distance that noise carries.

11.4. Feedback

We welcome your constructive feedback on how we can improve our products, including this manual. Testimonials for our hydro products can be view at www.powerspout.com/testimonials/

As EcoInnovation endeavors to reduce their footprint in many different ways, e.g. to save on paper and airfreight, this manual is only supplied electronically to customers. We encourage users to minimize printing where appropriate and to provide feedback via our website or via email (see Contact details inside front cover).

12. Units and conversions

- An **ampere** (amp, A) is the unit of measurement of electric current produced in a circuit by 1 volt acting through a resistance of 1 ohm.
- A **Btu** or British Thermal Unit is a standard unit for measuring the quantity of heat energy equal to the quantity of heat required to raise the temperature of 1 pound (16 ounces) of water by 1 degree Fahrenheit.
- A **current** is a flow of electrons in an electrical conductor. The strength or rate of movement of the electricity is measured in amperes.
- An **ohm** is the unit of measurement of electrical resistance. It is the resistance of a circuit in which a potential difference of 1 volt produces a current of 1 ampere.
- A **Watt** is the electrical unit of power: that is, the rate of energy transfer equivalent to 1 ampere flowing under a pressure of 1 volt at unit power factor.
- A **Watthour** is an electric energy unit of measure equal to 1 Watt of power supplied to (or taken from) an electric circuit steadily for 1 hour.

Volts x Amps = Watts

To convert	To	Multiply by
centimeters	Inches	0.3937
sq millimeters	sq inches	0.0015
meters	Feet	3.2808
miles per hour	Feet per second	1.4667
liters	Gallons	0.2641
liters per second	Gallons per minute	15.900
kilowatts	horsepower (electrical)	1.3405
degrees Celsius	degrees Fahrenheit	x 9/5 +32

To convert	To	Multiply by
inches	Centimeters	2.5400
Feet	Meters	0.3048
feet per second	Miles per hour	0.6819
gallons	Liters	3.7854
gallons per minute	Liters per second	0.0631
horsepower (electrical)	Kilowatts	0.7460
degrees Fahrenheit	degrees Celsius	-32 x 5/9

13. Warranty and disclaimer

The following applies to complete water turbines only and hence excludes kit sets and parts. Trade customers on selling this product must facilitate warrantee claims with the final client. EcolInnovation will only deal with the Trade customer in such cases.

Our warranty is valid provided the turbine has been correctly installed, commissioned and maintained over the duration of its use. The end user must return installation details² to EcolInnovation and keep a log book to record maintenance activity. EcolInnovation may request to see the log book and pictures of the installation and failed component prior to processing any warrantee claim.

Please also refer to warranty upgrades and support options as detailed on our web site.

EcolInnovation is confident in the performance, reliability and cost effectiveness of our range of water turbines. Hence we offer you:

- Full refund if you are not satisfied after the turbine has been running at your site for a 30-day period (this must occur within 3 months of dispatch) and EcolInnovation must be given the opportunity to rectify the problem. Clients need to pay for return freight cost to NZ, and the turbine must be returned in as new condition for a full refund.
- Performance guaranteed if our installation advice is followed for turbines that have output power greater than 200 W. Below 200 W a margin of +/- 20% applies.
- 2-year warranty from the time of purchase (invoice date), subject to maintenance specified in the PowerSpout Installation Manual including re-lubrication and replacement of bearings.
- Extended warranty available up to 10 years (premium per additional year).
- If there is a problem email us a picture of the failed part and we will fix it by dispatching a replacement part to you promptly. The labor cost to fit this part to your turbine is not covered under this warranty. The 2-year warranty is limited to the supply of replacement parts within 2 years of initial purchase.
- The cost of any single replacement part excluding the casing (outside the 2 year warranty period) for the original purchaser of our turbine will not be more than \$200 US plus freight (5 year limit from purchase date of turbine).
- If you can find a similar quality retail product advertised by a manufacturer or authorized dealer at a more competitive price, we will beat it by 20%. We will require an original copy of the advertisement. This offer excludes trade specials and second-hand units.
- Our maximum liability is limited to the full amount paid for the turbine. If you are an overseas customer that has purchased this equipment by mail order over the internet then this is the maximum extent of our liability.
- EcolInnovation reserves the right to improve the product and alter the above conditions without notice. Always ensure you are reading the latest version by downloading it from www.powerspout.com

EcolInnovation takes safety very seriously and we endeavor to reduce all risks to the extent possible and warn you of hazards. We encourage you to have the PowerSpout installed by a professional renewable energy installer if you do not have the skill, qualifications and experience to install this equipment safely. Customers that ignore such risks and advice do so at their own risk.

² The warranty is only valid for 12 months if no documentation (see Section 11.2) is returned within 11 months of sale

14. Annex I: Flow calculations and generator options

Table 7. PowerSpout LH1500 and LH1500 Pro

PowerSpout LH1500 and Pro (12/24/48 via MPPT regulators)											MPPT regulators up to 150 OCV			MPPT Regulators & Inverters up to 250 OCV			Grid tied inverters up to 400 OCV			Grid tied inverters up to 500 OCV		
Head		Flow approx		Watts	Efficiency	RPM	Runaway RPM	W/RPM	*Draft Tube I.D. mm	Watts lost in Draft tube	Stator fitted	Open Circuit Voltage	Running Voltage	Stator fitted	Open Circuit Voltage	Running Voltage	Stator fitted	Open Circuit Voltage	Running Voltage	Stator fitted	Open Circuit Voltage	Running Voltage
m	ft	l/s	GPM																			
1.0	3.3	24.8	394	91	37.5	688	1032	0.13	190.00	9	100-7s-2p-star	137	69	80-7s-2p-delta	205	103	80-7s-2p-star	361	181	80-14s-1p-delta	411	205
1.1	3.6	26.0	413	107	38.0	722	1083	0.15	190.00	11	100-7s-2p-star	144	72	80-7s-2p-delta	215	108	80-7s-2p-star	379	189	80-14s-1p-delta	431	215
1.2	3.9	27.1	431	123	38.5	754	1131	0.16	190.00	12	100-7s-2p-star	150	75	80-7s-2p-delta	225	113	80-7s-2p-star	396	198	80-14s-1p-delta	450	225
1.3	4.3	28.2	449	176	49.0	785	1177	0.22	190.00	14	80-2s-7p-star	118	59	80-7s-2p-delta	234	117	100-14s-1p-star	313	157	80-14s-1p-delta	468	234
1.4	4.6	29.3	466	199	49.5	814	1221	0.24	190.00	16	80-2s-7p-star	122	61	80-7s-2p-delta	243	122	100-14s-1p-star	325	162	80-14s-1p-delta	486	243
1.5	4.9	30.3	482	223	50.0	843	1264	0.26	190.00	17	80-2s-7p-star	126	63	100-14s-1p-delta	192	96	100-14s-1p-star	336	168	80-7s-2p-star	442	221
1.6	5.2	31.3	498	248	50.4	870	1306	0.28	190.00	19	80-2s-7p-star	130	65	100-14s-1p-delta	198	99	100-14s-1p-star	347	174	80-7s-2p-star	457	228
1.7	5.6	32.3	514	272	50.5	897	1346	0.30	190.00	21	80-2s-7p-star	134	67	100-14s-1p-delta	205	102	100-14s-1p-star	358	179	80-7s-2p-star	471	236
1.8	5.9	33.2	528	297	50.6	923	1385	0.32	190.00	23	80-2s-7p-star	138	69	100-14s-1p-delta	211	105	100-14s-1p-star	368	184	80-7s-2p-star	485	242
1.9	6.2	34.1	543	323	50.7	949	1423	0.34	190.00	25	80-2s-7p-star	142	71	100-14s-1p-delta	216	108	100-14s-1p-star	378	189	60-7s-2p-delta	413	206
2.0	6.6	35.0	557	349	50.8	973	1460	0.36	190.00	27	80-2s-7p-star	146	73	100-14s-1p-delta	222	111	100-14s-1p-star	388	194	60-7s-2p-delta	423	212
2.1	6.9	35.9	571	376	50.9	997	1496	0.38	190.00	29	80-2s-7p-star	149	75	100-14s-1p-delta	227	114	100-14s-1p-star	398	199	60-7s-2p-delta	434	217
2.2	7.2	36.7	584	404	51.0	1021	1531	0.40	190.00	31	80-2s-7p-star	153	76	100-14s-1p-delta	233	116	80-7s-2p-delta	305	152	60-7s-2p-delta	444	222
2.3	7.5	37.6	597	433	51.1	1044	1565	0.42	190.00	33	100-7s-2p-delta	119	59	100-14s-1p-delta	238	119	80-7s-2p-delta	312	156	60-7s-2p-delta	454	227
2.4	7.9	38.4	610	463	51.2	1066	1599	0.43	190.00	35	100-7s-2p-delta	122	61	100-14s-1p-delta	243	122	80-7s-2p-delta	318	159	60-7s-2p-delta	464	232
2.5	8.2	39.2	623	493	51.3	1088	1632	0.45	190.00	37	100-7s-2p-delta	124	62	100-7s-2p-star	217	109	80-7s-2p-delta	325	162	60-7s-2p-delta	473	237
2.6	8.5	39.9	635	524	51.4	1110	1664	0.47	190.00	40	100-7s-2p-delta	126	63	100-7s-2p-star	221	111	80-7s-2p-delta	331	166	60-7s-2p-delta	483	241
2.7	8.9	40.7	647	555	51.5	1131	1696	0.49	240.00	16	100-7s-2p-delta	129	64	100-7s-2p-star	226	113	80-7s-2p-delta	338	169	60-7s-2p-delta	492	246
2.8	9.2	41.5	659	587	51.6	1151	1727	0.51	240.00	17	100-7s-2p-delta	131	66	100-7s-2p-star	230	115	80-7s-2p-delta	344	172	80-7s-2p-delta	344	172
2.9	9.5	42.2	671	620	51.7	1172	1758	0.53	240.00	18	100-7s-2p-delta	134	67	100-7s-2p-star	234	117	80-7s-2p-delta	350	175	80-7s-2p-delta	350	175
3.0	9.8	42.9	682	654	51.8	1192	1788	0.55	240.00	19	100-7s-2p-delta	136	68	100-7s-2p-star	238	119	80-7s-2p-delta	356	178	80-7s-2p-delta	356	178
3.1	10.2	43.6	693	688	51.9	1212	1817	0.57	240.00	20	100-7s-2p-delta	138	69	100-7s-2p-star	242	121	80-7s-2p-delta	362	181	80-7s-2p-delta	362	181
3.2	10.5	44.3	705	723	52.0	1231	1846	0.59	240.00	21	100-7s-2p-delta	140	70	100-7s-2p-star	246	123	80-7s-2p-delta	367	184	80-7s-2p-delta	367	184
3.3	10.8	45.0	715	759	52.1	1250	1875	0.61	240.00	22	100-7s-2p-delta	143	71	80-2s-7p-star	187	94	80-7s-2p-delta	373	187	80-7s-2p-delta	373	187
3.4	11.2	45.7	726	795	52.2	1269	1903	0.63	240.00	23	100-7s-2p-delta	145	72	80-2s-7p-star	190	95	80-7s-2p-delta	379	189	80-7s-2p-delta	379	189
3.5	11.5	46.3	737	832	52.3	1287	1931	0.65	240.00	24	100-7s-2p-delta	147	73	80-2s-7p-star	193	96	80-7s-2p-delta	384	192	80-7s-2p-delta	384	192
3.6	11.8	47.0	747	870	52.4	1306	1959	0.67	240.00	25	100-7s-2p-delta	149	74	80-2s-7p-star	196	98	80-7s-2p-delta	390	195	80-7s-2p-delta	390	195
3.7	12.1	47.6	758	908	52.5	1324	1986	0.69	240.00	26	Not possible use 250vdc regulator			60dcHP-1s-12p-star	185	92	60dcHP-2s-6p-star	371	186	60dcHP-2s-6p-star	371	186
3.8	12.5	48.3	768	947	52.6	1341	2012	0.71	240.00	28				60dcHP-1s-12p-star	187	94	60dcHP-2s-6p-star	376	188	60dcHP-2s-6p-star	376	188
3.9	12.8	48.9	778	986	52.7	1359	2038	0.73	240.00	29				60dcHP-1s-12p-star	190	95	60dcHP-2s-6p-star	381	191	60dcHP-2s-6p-star	381	191
4.0	13.1	49.5	788	1026	52.8	1376	2064	0.75	240.00	30				60dcHP-1s-12p-star	192	96	60dcHP-2s-6p-star	386	193	60dcHP-2s-6p-star	386	193
4.1	13.5	50.2	798	1067	52.9	1393	2090	0.77	240.00	31				60dcHP-1s-12p-star	194	97	60dcHP-2s-6p-star	391	195	60dcHP-2s-6p-star	391	195
4.2	13.8	50.8	807	1109	53.0	1410	2115	0.79	240.00	32				60dcHP-1s-12p-star	197	98	60dcHP-2s-6p-star	396	198	60dcHP-2s-6p-star	396	198
4.3	14.1	51.4	817	1151	53.1	1427	2140	0.81	240.00	33				60dcHP-1s-12p-star	199	100	60dcHP-3s-4p-delta	342	171	60dcHP-2s-6p-star	400	200
4.4	14.4	52.0	826	1193	53.2	1443	2165	0.83	240.00	34				60dcHP-1s-12p-star	201	101	60dcHP-3s-4p-delta	346	173	60dcHP-2s-6p-star	405	202
4.5	14.8	52.5	836	1236	53.3	1460	2190	0.85	240.00	35				60dcHP-1s-12p-star	204	102	60dcHP-3s-4p-delta	350	175	60dcHP-2s-6p-star	409	205
4.6	15.1	53.1	845	1280	53.4	1476	2214	0.87	240.00	37				60dcHP-1s-12p-star	206	103	60dcHP-3s-4p-delta	354	177	60dcHP-2s-6p-star	414	207
4.7	15.4	53.7	854	1325	53.5	1492	2238	0.89	240.00	38				60dcHP-1s-12p-star	208	104	60dcHP-3s-4p-delta	358	179	60dcHP-2s-6p-star	418	209
4.8	15.7	54.3	863	1370	53.6	1508	2261	0.91	240.00	39				60dcHP-1s-12p-star	210	105	60dcHP-3s-4p-delta	362	181	60dcHP-2s-6p-star	423	211
4.9	16.1	54.8	872	1415	53.7	1523	2285	0.93	240.00	40				60dcHP-1s-12p-star	212	106	60dcHP-3s-4p-delta	366	183	60dcHP-2s-6p-star	427	214
5.0	16.4	55.4	881	1462	53.8	1539	2308	0.95	240.00	42				60dcHP-1s-12p-star	215	107	60dcHP-3s-4p-delta	369	185	60dcHP-2s-6p-star	432	216